

STUDY OF OBJECT DETECTION AND READING (LICENSE PLATE DETECTION AND READING)

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

Master of Technology

In

Telematics and signal processing

By

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Roll no: 209EC 1107



**Department of Electronics & Communication Engineering
National Institute of Technology
Rourkela
2011**

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CERTIFICATE

This is to certify that the thesis titled “**STUDY OF OBJECT DETECTION AND READING**” submitted by Mr. **G NANDA KISHORE** in partial fulfilment of the requirements for the award of Master of Technology degree **Electronics & Communication Engineering** with specialization in “**Telematics and Signal Processing**” during session 2009-2011 at National Institute Of Technology, Rourkela (Deemed University) is an authentic work by him under my supervision and guidance.

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ABSTRACT

Object detection means finding the location of the object and recognizing what it is. The techniques used for the object detection are feature matching algorithm, pattern comparison and boundary detection. The feature matching algorithm is used to find the best matching object in the knowledge base and to implement the reconstruction of the object recognized.

Our object detection is to detect the license plate detection of the car. To detect the license plate of a car first pre-process the image. The commonly license plate locating algorithms include line detection method, neural networks method, fuzzy logic vehicle license plate locating method. “**Connected component analysis**” is very easy technique than these techniques.

In the pretreatment process we first crop the image. After this we convert the color image to gray level image. After converting into gray level that image is filtered using three different types of filters. They are Average, Median, Weiner filters. After deciding the good filter we will apply the segmentation process using edge detection. After finding the edges we will give the numbers to each connected component and store all the connected components in a matrix called labeling matrix. Extract the required connected component using the labeling matrix and store that in an image. Compare this template with our database using template matching technique.

Template matching technique uses the correlation procedure. We will find the correlation coefficient between the two templates. Depending upon the correlation coefficient we will find that how much the two templates are similar to each other.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subfield of digital signal processing, digital image processing has many advantages over analog image processing; it allows a much wider range of algorithms to be applied to input data, and can avoid problems such as the build-up of noise and signal distortion during processing. Image segmentation refers to the process of partitioning a digital image into multiple regions (set of pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in an image. In this thesis the various popular fuzzy techniques for image segmentation are studied. Various methods for better clustering and segmentation have been developed. The algorithms or methods developed are meant for online and real time applications like television, camera phone, etc.

An image may be defined as a two dimensional function, $f(x,y)$ where x and y are spatial coordinates and the amplitude of f at any pair of coordinates (x,y) is called the

“Intensity” or “gray level” of the image at that point. The field of digital image processing refers to the processing digital images by means of a digital computer.

1.2 Fundamental in Digital Image Processing:

Digital image processing is a subset of the electronic domain wherein the image is converted to an array of small integers, called *pixels* (derived from *picture element*), representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware. Digital image processing, either as enhancement for human observers or performing autonomous analysis, offers advantages in cost, speed, and flexibility, and with the rapidly falling price and rising performance of personal computers it has become the dominant method in use.

An image is denoted by two dimensional functions of the form $f(x, y)$. The value or amplitude of f at spatial coordinates (x, y) is a positive scalar quantity whose physical meaning is determined by the source of the image. In a digital image, (x, y) , and the magnitude of f are all finite and discrete quantities. It is a hard task to distinguish between the domains of image processing and any other related area such as computer vision. But the two areas are quite different in the kind of output we get from them. **Computer vision** is the science and technology of machines that see. As a scientific discipline, computer vision is concerned with the theory for building artificial systems that obtain information from images. The image data can take many forms, such as a video sequence, views from multiple cameras, or multi-dimensional data from a medical scanner. In computer vision, the input is a digital image and the output is some representation of its interesting features. Image processing is often used in computer vision as a pre-processing step. Image processing is defined as an area when both input and output are images.

As a technological discipline, computer vision seeks to apply the theories and models of computer vision to the construction of computer vision systems.

The organization of a computer vision system is highly application dependent. Some systems are stand-alone applications which solve a specific measurement or detection problem, while other constitute a sub-system of a larger design which, for example, also contains sub-

systems for control of mechanical actuators, planning, information databases, man-machine interfaces, etc. The specific

Implementation of a computer vision system also depends on if its functionality is pre-specified or if some part of it can be learned or modified during operation. There are, however, typical functions which are found in many computer vision systems.

1. Image acquisition: A digital image is produced by one or several image sensor which, besides various types of light-sensitive cameras, includes range sensors, tomography devices, radar, ultra-sonic cameras, etc. Depending on the type of sensor, the resulting image data is an ordinary 2D image, a 3D volume, or an image sequence. The pixel values typically correspond to light intensity in one or several spectral bands (gray images or colour images), but can also be related to various physical measures, such as depth, absorption or reflectance of sonic or electromagnetic waves, or nuclear magnetic resonance.

2. Pre-processing: Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is usually necessary to process the data in order to assure that it satisfies certain assumptions implied by the method. Examples are

- (a) Re-sampling in order to assure that the image coordinate system is correct.
- (b) Noise reduction in order to assure that sensor noise does not introduce false information.
- (c) Contrast enhancement to assure that relevant information can be detected.
- (d) Scale space representation to enhance image structures at locally appropriate scales.

3. Feature extraction: Image features at various levels of complexity are extracted from the image data. Typical examples of such features are

- (a) Lines, edges and ridges.
- (b) Localized interest points such as corners, blobs or points.

More complex features may be related to texture, shape or motion.

4. Detection/Segmentation: At some point in the processing a decision is made about which image points or regions of the image are relevant for further processing. Examples are

- (a) Selection of a specific set of interest points
- (b) Segmentation of one or multiple image regions which contain a specific object of interest.

5. High-level processing: At this step the input is typically a small set of data, for example a set of points or an image region which is assumed to contain a specific object. The remaining processing deals with, for example:

- (a) Verification that the data satisfy model-based and application specific assumptions.
- (b) Estimation of application specific parameters, such as object pose or object size.
- (c) Classifying a detected object into different categories

Hence it can be said that *image segmentation* forms an integral part of computer vision systems and *is more an area of computer vision than image processing*.

Image restoration is an area that also deals with improving the appearance of an image. However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation. Enhancement, on the other hand, is based on human subjective preferences regarding what constitutes.

Color image processing is an area that has been gaining in importance because of the significant increase in the use of digital images over the Internet a “good” enhancement result.

Compression, as the name implies, deals with techniques for reducing the storage required saving an image, or the bandwidth required transmitting it. Although storage technology has improved significantly over the past decade, the same cannot be said for transmission capacity. This is true particularly in uses of the Internet, which are characterized by significant pictorial content. Image compression is familiar (perhaps inadvertently) to most users of

computers in the form of image file extensions, such as the jpg file extension used in the JPEG (Joint Photographic Experts Group) image compression standard.

1.3 Problem Definition:

Object detection means finding the location of the object and recognizing what it is. The techniques used for the object detection are feature matching algorithm, pattern comparison and boundary detection. The feature matching algorithm is used to find the best matching object in the knowledge base and to implement the reconstruction of the object recognized.

There are two mainly two object recognition models

1. The structural description model

2. Image base model

The first one believe that the main goal of the object recognition is to reconstruct the three dimensional description of the object. The second one believe that the regional features on the object are not sufficient to represent a 3D object and requires normalization and then by means of matching with similar view of the object to finalize the reconstruction. Object recognition algorithms such as feature fitting, template fitting, and boundary matching could be thought as the application of the above models. However recognizing an object based on the regional feature appears unstable, since different objects may have similar regional features. Either the structural description model or the image based model appears lack of consideration of shape knowledge.

Our object detection is to detect the license plate detection of the car. To detect the license plate of a car first pre-process the image. The commonly license plate locating algorithms include line detection method, neural networks method, fuzzy logic vehicle license plate locating method. “**Connected component analysis**” is very easy technique than these techniques.

1.4 Thesis Layout:

In **CHAPTER 1** I explained about the fundamentals of digital image processing and problem definition.

CHAPTER 2 various methods and approaches for detecting and reading of the digital car image are discussed.

CHAPTER 3 This chapter contains the proposed connected component analysis technique and algorithm for the proposed technique.

CHAPTER 4 This chapter contains the results of the proposed technique.

CHAPTER 5 This chapter contains the conclusion and future work that can be done.

CHAPTER 2

LITERATURE REVIEW

In general, it is possible to divide previous passive studies into 2 parts. The one using Artificial Neural Networks and others using other methods. In Neural network systems, each character is introduced as an input data to the system. The system learns these characters. After that, it compares the input data characters to the existing characters. As a result, the character which has very similar rate is activated.

In this study, [1] is used for Inductive Learning Based Method and SVM method. Inductive Learning Based Method is used to divide all classes into smaller groups. SVM method is used for classification of these groups. All these methods are applied on the plate characters. Then, a training process is used for each character.

This system [2] is a web based system. This system consists of three modules:

- Creating digital image form the video signals, using hardware for this;
- Using pattern recognition and artificial intelligence for plate recognition;
- Accessing to the database from web browser and run query for vehicles

In this system [3] morphological operators are used for preprocessing. After preprocessing, Template Matching is used for character recognition. This system is used for Macao-style license plates.

In this study, it is the first time that the plate image is normalized [4]. Scaling and cross-validation are applied for remove the outliers and find clear parameters for SVM method. Then use SVM method for character recognition. Correct recognition rate is higher than neural network systems.

This method [5] is applicable in camera-in-motion applications. Images are acquired via a webcam. The light conditions, background and position of the vehicle are not important for character recognition. This method can localize different sizes of the plate from the image. After localization of the plate, the characters are segmented. Multiple neural networks are used for character recognition. The correction rate is %95 in this method. This application was used in University of Malaga (Spain) in the entrance of the Computer Science building.

Sobel color edge detector is used for detecting vertical edges in this study [6]. Then, the invalid edge is eliminated. The license plate region was searched by using template matching. Mathematical morphology and connected component analysis was used for segmentation. Radial basis function neural network was used for character recognition. This system is also successful in night hours and daytime real conditions.

Plate location is found by using plate background and the character's color in this study [7]. For segmentation, the column sum vector is obtained. The Artificial Neural Network is used for character recognition.

This system is designed for Islamabad Computerized Number Plates [8]. SCAN_NP algorithm is developed for plate extract. This algorithm can find candidate plates. The algorithm brings out these candidate objects which would turn out to be the plate characters. The objects have horizontal and vertical lines. This algorithm scans the image to remove the noises from the image. Neural Network and template matching is used for character recognition. The correction rate is %90 in this method.

This method [9] is used in off-line Thai license plate recognition. Hausdorff Distance technique is used for recognition. The correction rate in this method is %92.

This method [10] is used for Chine license plate recognition. The plate image is converted into a binary image. Then the noises are removed from the image. The skeleton is used for generating the feature of the character. Then the character is normalized to size 8*16 pixels. The plate image is processed in the Back-Propagation Neuronal Network for recognition after being normalized. Back-Propagation Neuronal Network is used for character recognition

This method [11] is not used to preprocess for recognition. Image transformation is applied for original license plate picture. After transformation process, in the database, the number of the input and the data increase. Convolution neural network is used for character recognition. The correction rate in this method is %98..

This method [12] has two modules: plate locating and plate segmentation modules. Fuzzy geometry is used for the first module. Fuzzy C mean is used as the second module. The correction rate for segmentation is %94.24

In this method [13] blob labeling and clustering are used for segmentation. The studies of Kirsch, Sobel, Laplacian, Wallis, Prewitt, Frei Chen on edge detectors are compared and

contrasted, and Kirsch's edge detector is regarded as the most appropriate one among others. This method is used neural network for classification and recognition character.

Field-programmable gate array (FPGA) is used in this study [14]. Gabor filter, threshold and connected component labeling algorithms are used for finding plate location. After segmentation, a self-organizing map (SOM) neural network is used for character recognition. Hardware is used in this system. Then, the system spends less time than computer-based recognition system for does character recognition. Moreover, the system is mobile.

Two-layer Markow network is used for segmentation and character recognition in this study [15]. In this method "8" and "B" can be mixed. This study is made synthesising with Housdorff and Shape context methods.

A median filter is used for removing noises from plate image in this method [16]. Hough transform is used for rotating the plate image when it is necessary. Adoptive threshold method is used for binarization. Segmentation is applied after binarization. FFM (Filled Function Method)-BPNN (BP Neural Network) algorithm is used for character recognition. This method is used for Chine character. And can be use for fingerprint and retina recognition.

In this paper [17], they use a different algorithm which is developed for Italian Highway Company to control the traffic flow. Their classification algorithm has two stages. One of them is parameters setting phase and the other is character classification by embedded Generative Models with using covariance matrix. They search for 7.000 different images of license plates. In this research, correct classification is 98.1% with using their algorithm which is called Generative Models.

In this study [18] Robert edge detector and morphology operator is used for finding plate edge from the picture. Horizontal and vertical projections are used for rotating plate image when it is needed. Least squares support vector machines are used for character recognition.

This method [19] is used different method for finding plate location from the picture. White and black pixels have different weight according to this method. Hence, this method uses this feature for finding plate location. Hybrid neural network is used for character recognition. The correction rate in this method is %97.

This method uses is [20] Ostu Threshold algorithm for converting into binary level for plate image. Character coordinates are used for character segmentation. Improved pattern

matching algorithm is used for character recognition. The correction rate is %98 in this method. Scanline checking is used for plate localization in this study [21]. Dynamic projection warping is used for character recognition.

This method [22] is about plate localization and character segmentation. AdaBoost algorithm is used for finding plate localization from the image. Vertical edge detection and horizontal projection histogram are used for upper and lower boundary disposal. Image binarization and vertical projection histogram are used for character segmentation. The correction rate is %96.4 in this method.

This method [23] uses composite colors for detecting the plate area of the image. Horizontal and vertical histograms are used for character segmentation. Artificial hippocampus algorithm is used for character recognition. The correction rate is %95 in this method.

This method [24] uses 2-level 2D discrete wavelet transform rather than conventional 1-level 2D discrete wavelet transform. The correlation rate in this method is 97% where in conventional method is only 80%.

This method [25] uses the Histogram method for finding the license plate. License plate images for the characteristics, according to plate the distribution of grey changes in the law of peak and valley was to locate the boundary plates. The use of the methods is proposed in this article, in a variety of weather conditions (including morning, noon, night, sunny and rainy days, etc.) and under the conditions of different backgrounds and the license plate location is 98.7%.

CHAPTER 3

IMAGE PRETREATMENT PROCESS

Our object detection is to detect the license plate detection of the car. To detect the license plate of a car first pre-process the image. The pre-process of the image can be done as follows.

3.1 Image Pre-treatment:

All vehicle images acquired through camera and image card are colour image and image format is not same. The commonly used image forms are JPEG and BMP. If treatment with acquired image directly, not only the image format is complex, moreover the computation data quantity is extremely huge, such license plate location cannot satisfy the request for fast and real-time. Therefore, the color image need to be formatted processing, transforming the JPEG image or the BMP image to DIB(Device Independent Bitmap) which favours the computer to process.

In the image pretreatment process we first crop the image using image cropping technique. **Cropping** refers to the removal of the outer parts of an image to improve framing, accentuate subject matter or change ratio. By considering the x and y coordinates of the car and also height and width, we can crop the digital image to our required image. After this we can get the exact car image. After cropping the image is shown in figure 2.

3.2 Gray Level:

The given image is a coloured image so convert that colour image into gray level image using gray level conversion. The coloured image contains red, green, blue colours. After converting it into gray level image it has only black, white and gray values. So now it becomes 8-bit image. The process needs to be done before the image is converted into binary level. The converted image is shown in figure 3.

3.3 Binary Level:

An image consists of numeric values between 0 - 255. The numerical value of the picture is reduced to two values with binary level. Thus, a 8 - bit image is converted into 2 - bit format. The threshold value must be determined for this conversion. Using a fixed threshold value is not correct because of external factors such as sunlight, shadows at real-plate images. A distribution histogram is useful for calculating threshold value. If the pixel value in the image is greater than threshold value, then the pixel value is shown as "0"; and if the image pixel' value is less then threshold value, the pixel value is shown as "1". In this way the image is converted to the binary level.

3.4 Histogram Distribution:

Expressing values on the image pixels graphically is called image histogram. In each point, pixels on the image histogram and the number of pixels can be seen by using the image histogram. This image histogram does not show positions of the pixels on the image, but shows distribution of light-dark areas on the image. The histogram distribution is required for the calculation of the threshold value. Histogram can be expressed mathematically with the following formula.

$$P(r_k) = n_k / n$$

Where r_k : k'nd gray level,

n_k : number of total pixels that have gray level,

n : Number of total pixels on the display,

Using the above formula we find the histogram of the image.

3.5 Histogram Equalization:

Histogram equalization is used to improve color distribution where the image is not clear. In an image, if pixel values are clustered into a specific number, this clustering would be reduced by using histogram equalization. If the image has light and dark areas then we do the histogram equalization for the pixels to be equally distributed.

In the next pretreatment process the image should be filtered to remove the unwanted noise stored in the image.

3.6 Spatial Filtering:

If the image has any noise, to remove that noise we do the filtering. The concept of filtering has its roots in the use of the Fourier transform for signal processing in the so-called frequency domain. If the filtering operations that are performed directly on the pixels of an image, we use the term spatial filtering to differentiate this type of process from the more traditional frequency domain filtering.

The process consists of simply moving the filter mask from point to point in an image. At each point (x, y) , the response of the filter at that point is calculated using the predefined relationship. For linear spatial filtering the response is given by a sum of products of the filter coefficients and the corresponding image pixels in the area spanned by the filter mask. In general the linear filtering of an image 'f' of size $M \times N$ with a filter mask of $m \times n$ is given by the expression:

$$g(x, y) = \sum_{s=-a}^{s=a} \sum_{t=-b}^{t=b} w(s, t) f(x + s, y + t)$$

Where $a = (m-1)/2$ and $b = (n-1)/2$

To generate a complete filtered image this equation must be applied for $x=0, 1, 2, \dots, M-1$ and $y=0, 1, 2, \dots, N-1$.

3.7 Smoothing Linear Filters:

The output of a smoothing, linear spatial filter is simply the average of the pixels contained in the neighborhood of the filter mask. These filters are sometime called "averaging filters". They are also called low pass filters.

The idea behind the smoothing filters is straightforward. By replacing the value of every pixel in an image by the average of the gray levels in the neighborhood

defined by the filter mask, this process results in an image with reduced sharp transitions in gray levels. Because random noise typically consists of sharp transitions in gray levels, the most obvious application of smoothing is noise reduction. The filtering masks are shown below.

1	1	1
1	1	1
1	1	1

1	2	1
2	4	2
1	2	1

Use of first filter yields the standard average of pixels under the mask. This can be best seen by substituting the coefficients of the mask into the below shown equation.

$$R = \sum_{i=1}^9 z_i$$

Which is the average of the gray levels of the pixels in the 3x3 neighborhood defined by the mask. The output of the average filter is shown in results. The output of Average filter is shown in figure 4.

3.8 Median Filter:

It is a order static filter. Order static filters are non-linear spatial filters whose response is based on ordering the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result. The best known example in this category is the median filter, which, as it's name implies, replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel.

Median filters are quite popular because, for certain types of random noise, they provide excellent noise reduction capabilities with considerably less blurring than linear smoothing filters. Median filters are particularly effective in the presence of impulse noise

also called salt and pepper noise because of its appearance as white and black dots superimposed on an image.

The median ϵ of a set of values is such that half the values in the set are less than or equal to ϵ and half are greater than or equal to ϵ . In order to perform median filtering at a point in an image we first the values of the pixels in question and its neighbors, determine their median and assign this value to that pixel. For example in a 3×3 neighborhood the median is the 5th largest value, in a 5×5 neighborhood the 13th largest value and so on. When several values in a neighborhood are same, all equal values are grouped. The principle function of median filters is to force points with distinct gray levels to be more like their neighbors. The output of the median filter is shown in the results. The output of Median filter is shown in figure 5.

3.9 wiener filter:

In this method the noise is consider as random variable and the objective is to find an estimate f^{\wedge} of the uncorrupted image f such that the mean square error between them is minimized. This error is given by

$$e^2 = E\{(f - f^{\wedge})^2\}$$

Where $E(.)$ is the expected value of the argument. It is assumed that the noise and image are uncorrelated. that one or the other has zero mean and the intensity levels in the estimate are a linear function of the levels in the degraded image. This result is known as *Wiener filter*. The output of wiener filter is shown in figure 6.

CHAPTER 4

CONNECTED COMPONENT ANALYSIS

4

After the filtering process is over we should do the segmentation process. The segmentation process is explained below.

4.1 Image Segmentation:

Segmentation of an image entails the division or separation of the image into regions of similar attribute. The basic attribute for segmentation is image amplitude- luminance for a monochrome image and colour components for a colour image. Image edges and textures are also useful attributes for segmentation. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image.

Segmentation does not involve classifying each segment. The segmentor only subdivides an image; it does not attempt to recognise the individual segments or their relationships to one another.

There is no theory of image segmentation. As a consequence, no single standard method of image segmentation has emerged. Rather, there are a collection of ad hoc methods that have received some degree of popularity. Because the methods are ad hoc, it would be useful to have some means of assessing their performance. Haralick and Shapiro (1) have established the following qualitative guidelines for “good” image segmentation:

(a) Regions of the image segmentation should be uniform and homogeneous with respect to some characteristic such as gray tone or texture.

4.2 Applications of segmentation:

Some of the practical applications of image segmentation are:

1. Medical Imaging
 - Locate tumours and other pathologies
 - Measure tissue volumes
 - Computer guided surgery
 - Diagnosis
 - Treatment planning
 - Study of anatomical structures
2. Locate objects in satellite images (roads, forests, etc.)
3. Face recognition
4. Fingerprint recognition
5. Automatic traffic controlling systems
6. Machine vision

4.3 Segmentation technique based on discontinuity property of pixels:

4.3.1 Detection of Discontinuities:

In this category, the approach is to partition an image based on abrupt changes in intensity, such as **edges** in an image. Three basic types of gray-level discontinuities that are mostly detected in a digital image are: points, lines and edges. The most common way to look for discontinuities is to run a mask through the image. For the 3x3 mask shown in fig. 4.1, this procedure involves computing the sum of products of the coefficient with the gray level contained in the region encompassed by the mask. That is, the response of the mask at any point in the image is given by

$$\begin{aligned} R &= w_1 z_1 + w_2 z_2 + \dots + w_9 z_9 \\ &= \sum_{i=1}^9 w_i z_i \end{aligned} \quad (2.1)$$

Where z_i is the gray level of the pixel associated with mask coefficient w_i . As usual, the response of the mask is defined with respect to its centre location.

4.3.2 Point detection:

Fig 4.1 Point detection mask

-1	-1	-1
-1	8	-1
-1	-1	-1

Using the mask shown in Fig. 4.1, we say that a point has been detected at the location on which the mask is centred if

$$|R| \geq T \quad (2.2)$$

Where T is a nonnegative threshold and R is given by (2.1).

4.3.3 Line detection:

Consider the masks in Fig. 4.2. If the first mask were moved around an image, it would respond more strongly to lines (one pixel thick) oriented horizontally. With a constant background, the maximum response would result when the line passed through the middle row of the mask. Similarly, the second mask in Fig. 4.2 responds to lines oriented at $+45^\circ$; the third mask to vertical lines; and the fourth mask to lines oriented at -45° direction.

Let R1, R2, R3, and R4 denote the responses of the masks in Fig. 4.2, from left to right, where R's are given by equation 2.1. Let the four masks be run through an image individually. If, at a certain point in the image, $|R_i| > |R_j|$, for all $j \neq i$, that point is said to be more likely associated with a line in the direction of the mask i .

-1	-1	-1
2	2	2
-1	-1	-1

Horizontal

[22]

-1	-1	2
-1	2	-1
2	-1	-1

$+45^\circ$

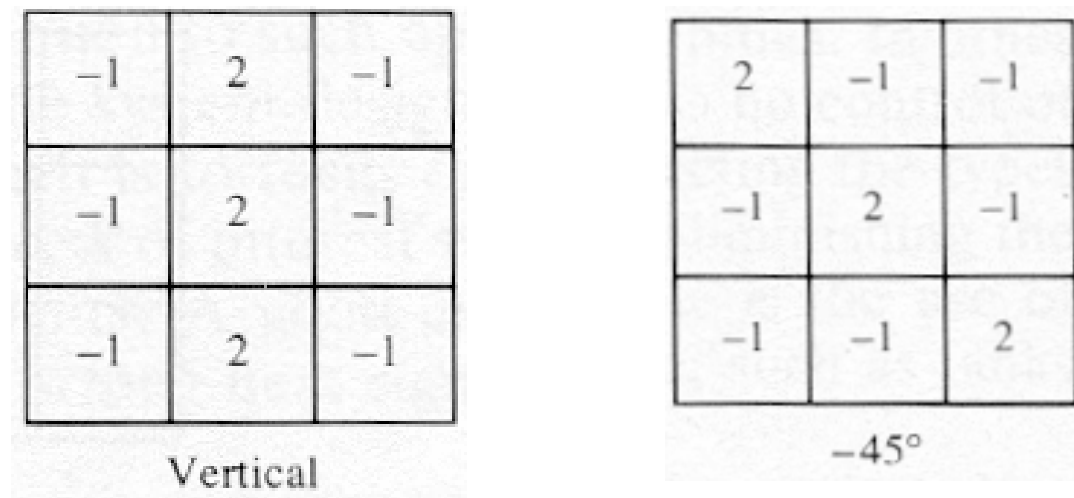


Fig 4.2 Line detection masks

The above shown are line detection masks

4.3.4 Edge detection:

Edge detection is an important step for image segmentation. The goal of edge detection process in a digital image is to determine the frontiers of all represented objects based on automatic processing of the colour or gray level information in each present pixel.

To extract the edges from the images, derivative edge detection operators or gradient operator, such as Sobel operator, Prewitt operator, Roberts's operator, and Laplacian operators are commonly used. A 3x3 mask is used for edge detection using the mentioned operators.

The reasons that Prewitt and Sobel edge detectors visually appear to better delineate object edges than the Roberts edge detector is attributable to their larger size, which provides averaging of small luminance fluctuations. The Sobel edge detector uses a weight of 2 in the centre coefficient. A weight of 2 is used to achieve some smoothing by giving more importance to the centre point. The Prewitt masks are simpler to implement than the Sobel masks, but the latter

have slightly superior noise-suppression characteristics, an important issue when dealing with derivatives. Note that the coefficients in all masks shown in Fig. 2.5 sum to 0, indicating that they give a response of 0 in areas of constant gray levels, as expected of a derivative operator.

-1	0
0	1

0	-1
1	0

These are ROBERTS masks

-1	0	1
-1	0	1
-1	0	1

-1	-1	-1
0	0	0
1	1	1

These are PREWITT edge detection masks

-1	0	1
-2	0	2
-1	0	1

-1	-2	-1
0	0	0
1	2	1

These are SOBEL edge detection masks

Fig 4.3 Edge Detection Masks

Canny edge detector

The Canny edge detection operator was developed by John F. Canny [57] in 1986 and uses a multi-stage algorithm to detect a wide range of edges in images. The method can be summarized as follows:

1. The image is smoothed using a Gaussian filter with a specified standard deviation, s , to reduce noise.
2. The local gradient, $g(x, y) = [G_x^2 + G_y^2]^{1/2}$, and edge direction, $\alpha(x, y) = \tan^{-1}(G_x / G_y)$, are computed at each point. Any of the first three techniques Prewitt, Sobel or Log edge detector can be used to compute G_x and G_y . An edge point is defined to be a point whose strength is locally maximum in the direction of the gradient.
3. The edge points determined in (2) give rise to ridges in the gradient magnitude image. The algorithm then tracks along the top of these ridges and sets to zero all pixels that are not actually on the ridge top so as to give a thin line in the output, a process known as *nonmaximal suppression*. The ridge pixels are then thresholded using two thresholds, T_1 and T_2 , with $T_1 < T_2$. Ridge pixels with values greater than T_2 are said to be “strong” edge pixels. Ridge pixels with values between T_1 and T_2 are said to be “weak” edge pixels.
4. Finally, the algorithm performs edge linking by incorporating the weak pixels that are 8-connected to the strong pixels.

The gradient-based edge detection method has been widely applied in practice and a reasonable edge map is obtained for most images. Nevertheless, they suffer from some practical limitations.

First, they need a smoothing operation to alleviate the effect of high spatial frequency in estimating the gradient. Usually this smoothing is applied to all pixels in the image including the edge regions, and so the edge is distorted and missed in some cases, in particular at junctions or corners. Secondly, the gradient magnitude alone is insufficient to determine meaningful edges because of the ambiguity caused by the underlying pixel pattern, especially in complex natural scenes. Thirdly, the gradient-based edge detection methods increase the computational complexity because calculations, such as square root and arctangent, to produce the gradient vector are required. Finally, for edge thresholding conventional gradient methods use one or two global edge thresholds for an input image. For example, the hysteresis thresholding proposed by Canny in many practical applications require not only the trial and error adjustment of two

thresholds to produce a satisfactory edge result for each different input image, but also the validity of the pre-adjusted thresholds.

After the completion of filtering process we apply the above three operators. Figure 7 shows the edge detection using “canny” operator. Figure 8 shows the edge detection using” prewitt” operator. Figure 9 shows the edge detection using” sobel” operator.

4.4 Algorithm:

A pixel ‘p’ at coordinates (x,y) has four horizontal and vertical neighbours whose coordinates are given by

$$(x+1,y),(x-1,y),(x,y+1),(x,y-1)$$

This set of pixels called the 4-neighbors of ‘p’ is denoted by $N_4(p)$. Each pixel is a unit distance from (x,y). The four diagonals of ‘p’ have coordinates are

$$(x+1,y+1),(x+1,y-1),(x-1,y+1),(x-1,y-1)$$

And are denoted by $N_D(p)$.

Connectivity between the pixels is a fundamental concept that simplifies the definition of numerous digital image concepts, such as regions and boundaries. To establish if two pixels are connected, it must be determined if they are neighbours and if their gray levels satisfy a specified criterion of similarity.

4-Adjacency: Two pixels p and q with values from V are 4-adjacent if q is in the set $N_4(p)$.

8-Adjacency: Two pixels p and q with values from V are 8-adjacent if q is in the set $N_8(p)$.

Steps in the algorithm:

- After the edge detection calculates the no. Of connected components formed by 8-adjacent connectivity.
- Store all the connected components in a matrix called “Labeling matrix(L)”.
- The matrix L contains the labels for the connected components in the segmented image. The elements of L are integer values greater than or equal to ‘0’.

- The pixels labeled 0 are the background. The pixels labeled 1 make up one object; the pixels labeled 2 make up a second object; and so on.
- Find the total no. Of connected objects in the Label matrix. Store that value in a variable “mx”.
- Search each connected component of the license plate below the threshold value “mx” and store that in an image .
- Extract the license plate numbers and alphabets and compare with our database using template matching.

After getting the edges of the image we apply the above algorithm on different types of operators and extract the characters of the license plate directly. For finding the characters we apply the template matching.

4.5 Template Matching:

After extracting the numbers and alphabets to read them we use template matching technique. Template matching is a technique in digital image processing for finding small parts of an image which match a template image. It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot, or as a way to detect edges in images.

Template matching can be subdivided between two approaches: feature-based and template-based matching. The feature-based approach uses the features of the search and template image, such as edges or corners, as the primary match-measuring metrics to find the best matching location of the template in the source image. The template-based, or global, approach, uses the entire template, with generally a sum-comparing metric (using SAD, SSD, cross-correlation, etc.) that determines the best location by testing all or a sample of the viable test locations within the search image that the template image may match up to.

We find the matching between the two images by using the CORRELATION. Correlation finds the similarity between the two templates. The similarity between the two templates can be found by using the CORRELATION COEFFICIENT. The range of correlation coefficient is from ‘-1’ to ‘+1’. If the value of the correlation coefficient is near to ‘+1’ then the two templates

are nearly same otherwise they are different. We found the correlation between the template and with our dataset.

The formula for correlation coefficient is shown below.

$$cor = \frac{\sum_{i=0}^{N-1} (x_i - \bar{x}) \cdot (y_i - \bar{y})}{\sqrt{\sum_{i=0}^{N-1} (x_i - \bar{x})^2 \cdot \sum_{i=0}^{N-1} (y_i - \bar{y})^2}}$$

If the value of the cor is near to '+1' then the two templates are nearly same.

x is the template gray level image

\bar{x} is the average grey level in the template image

y is the source image section

\bar{y} is the average grey level in the source image

N is the number of pixels in the section image

(N = template image size = columns * rows)

The values of all the correlation coefficients are shown in results.

The value of threshold we are using here is 0.85 to compare the *correlation coefficients*. If the value of the correlation coefficient is greater than 0.85 then that operator is best and that is recognised as the matching template.

CHAPTER 5

RESULTS

5

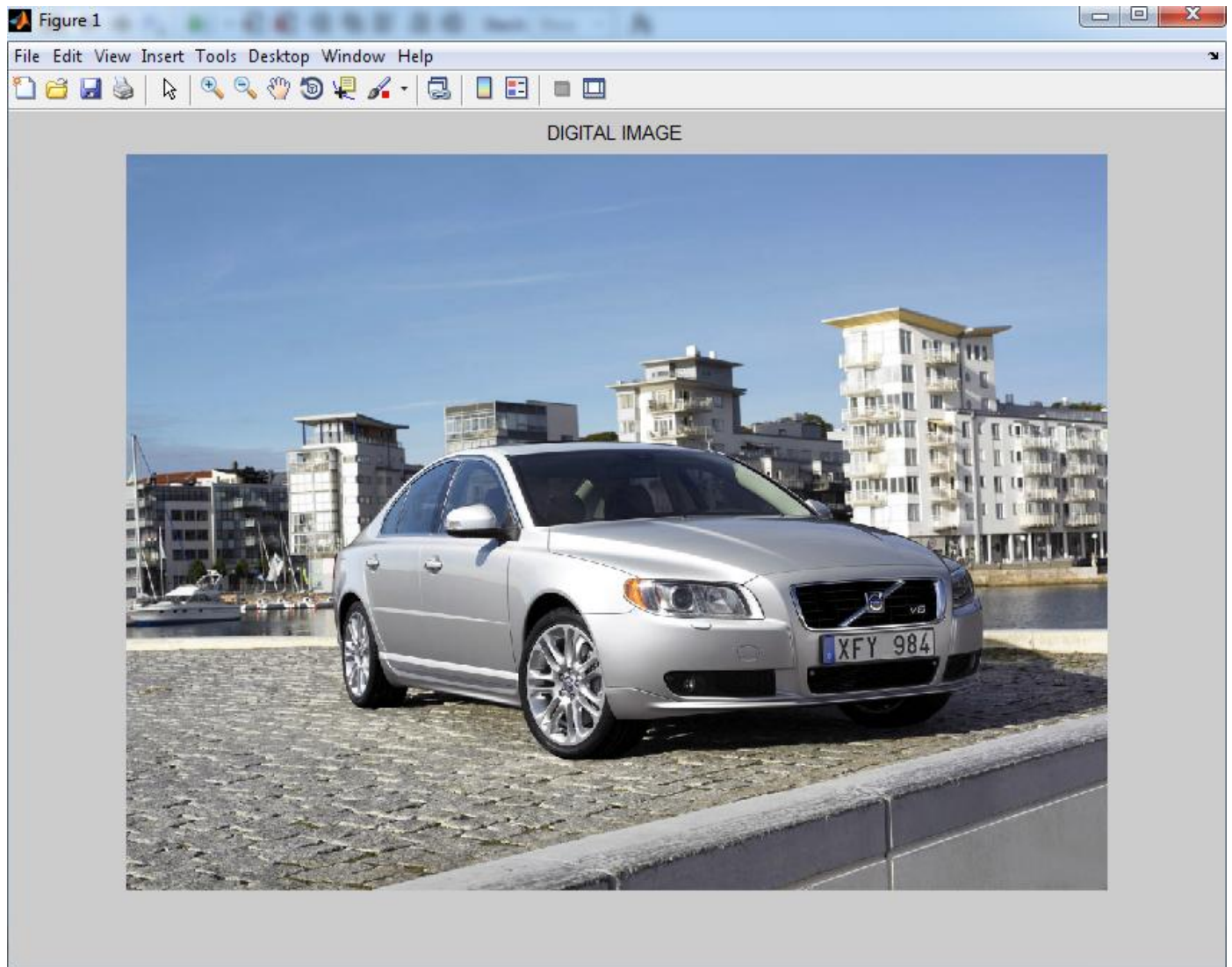


Figure 1: INPUT IMAGE FOR TESTING THE PROPOSED ALGORITHM

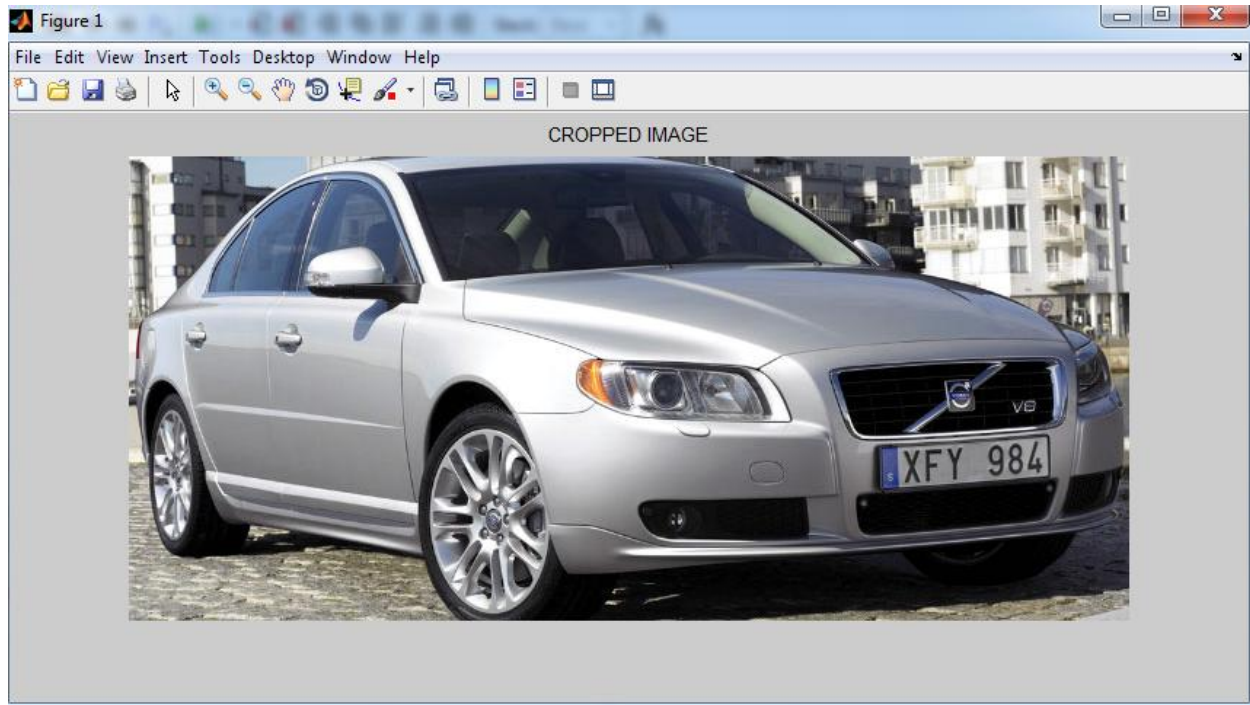


Figure 2: AFTER CROPPING USING THE IMAGE CROPPING TECHNIQUE



Figure 3: IMAGE AFTER CONVERSION FROM "RGB" TO "GRAY"

AVERAGE FILTER



Figure 4: OUTPUT OF “AVERAGE FILTER”

MEDIAN FILTER



Figure 5: OUTPUT OF “MEDIAN FILTER”

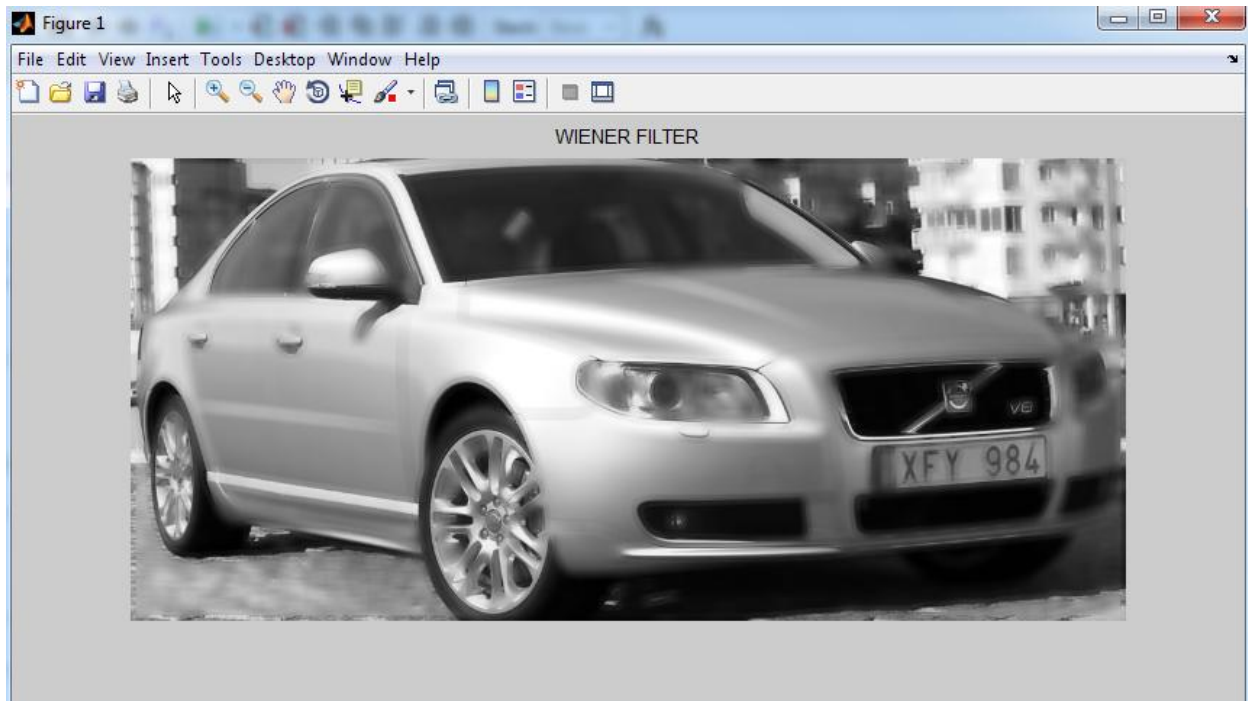


Figure 6: OUTPUT OF “WIENER FILTER”

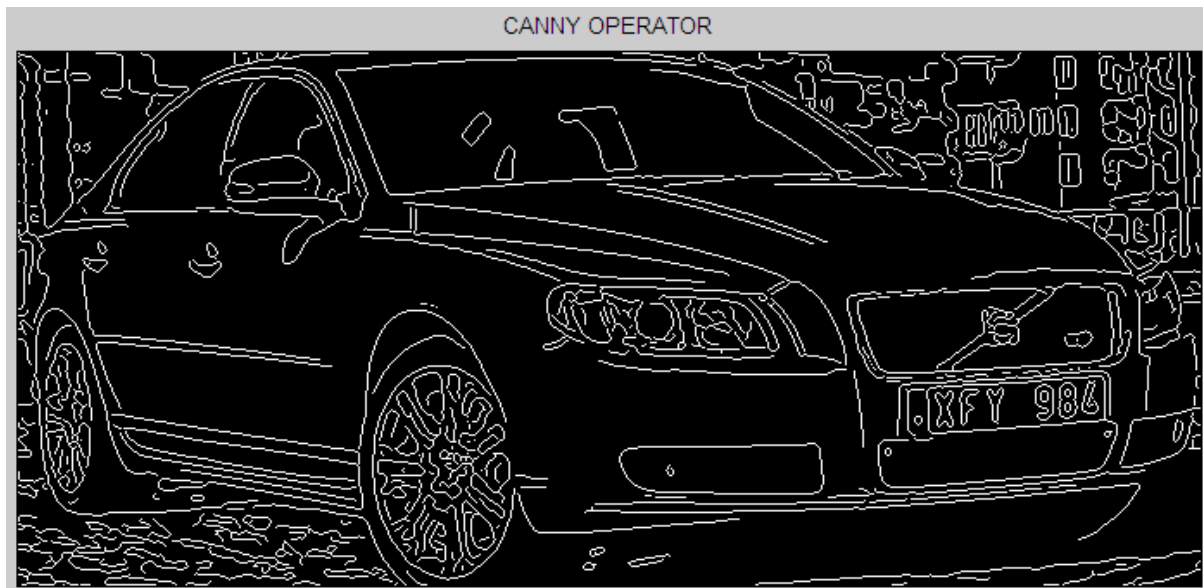


Figure 7: EDGE DETECTION USING “CANNY” OPERATOR

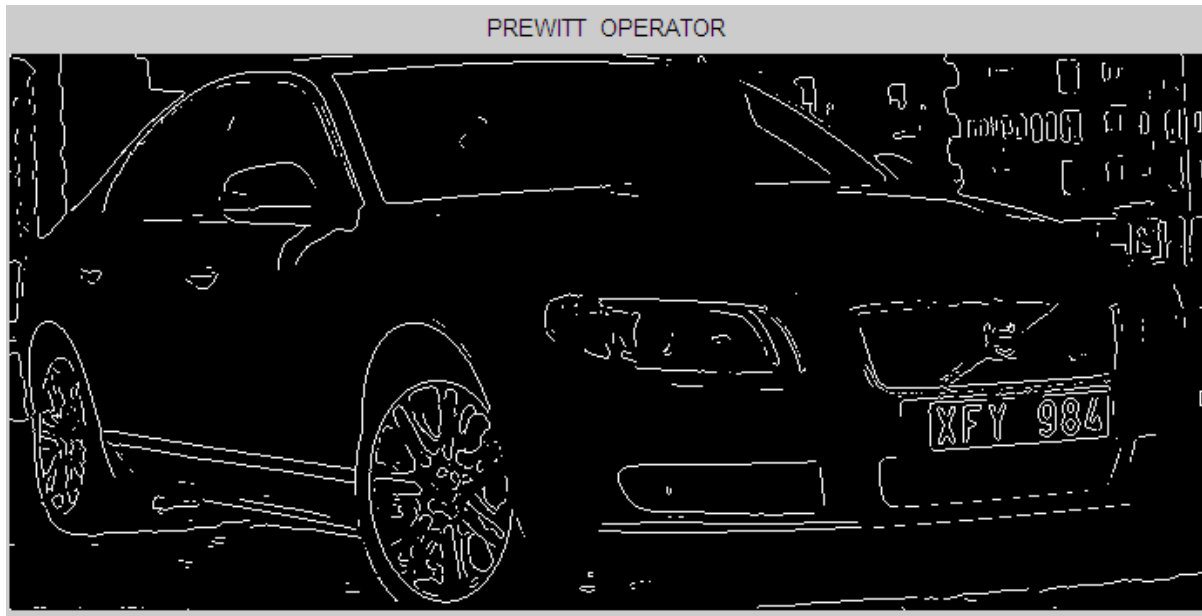


Figure 8: EDGE DETECTION USING “PREWITT” OPERATOR

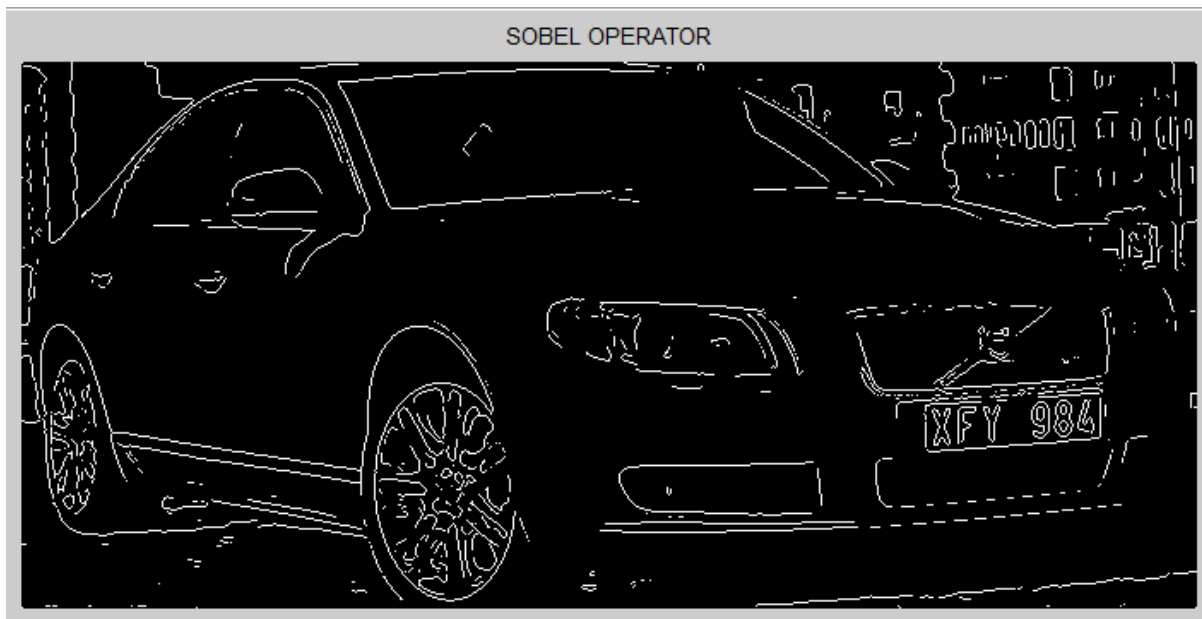


Figure 9: EDGE DETECTION USING “SOBEL” OPERATOR

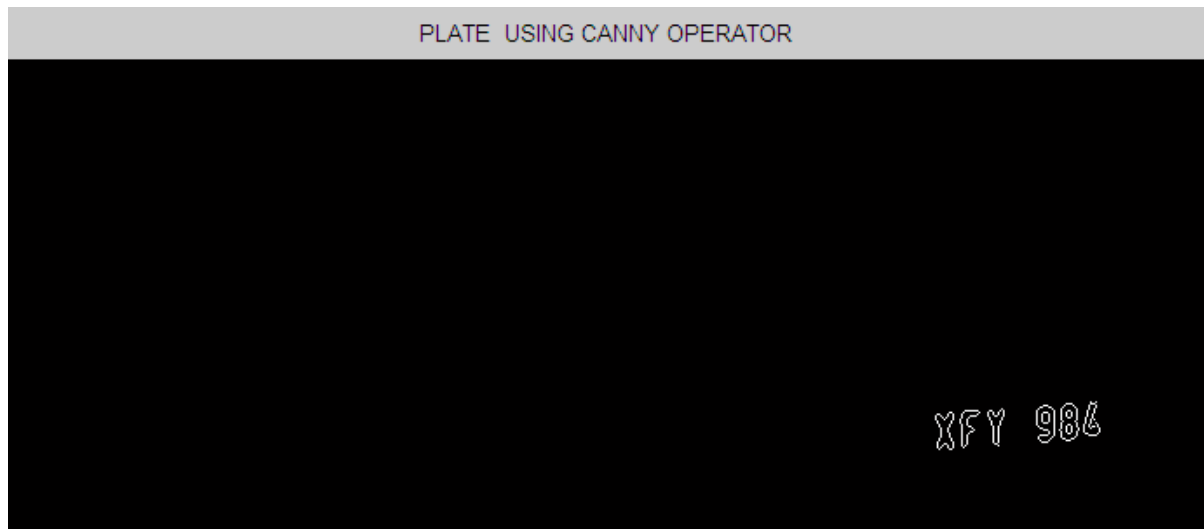


Figure 10: PLATE EXTRACTED USING “CANNY” OPERATOR

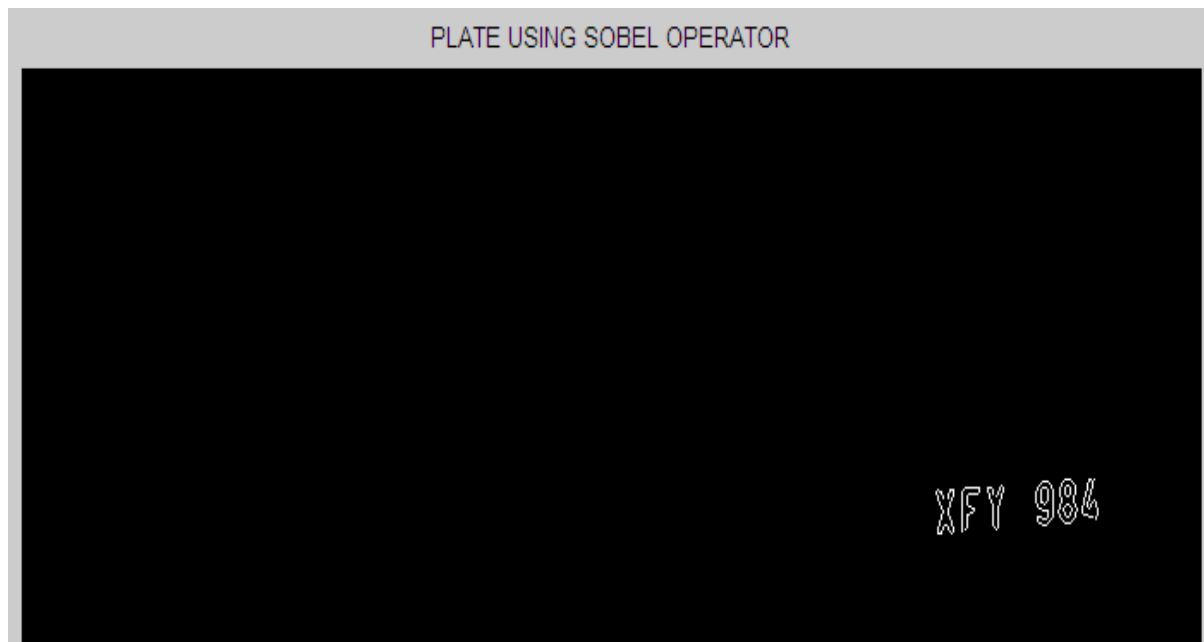


Figure 11: PLATE EXTRACTED USING “SOBEL” OPERATOR

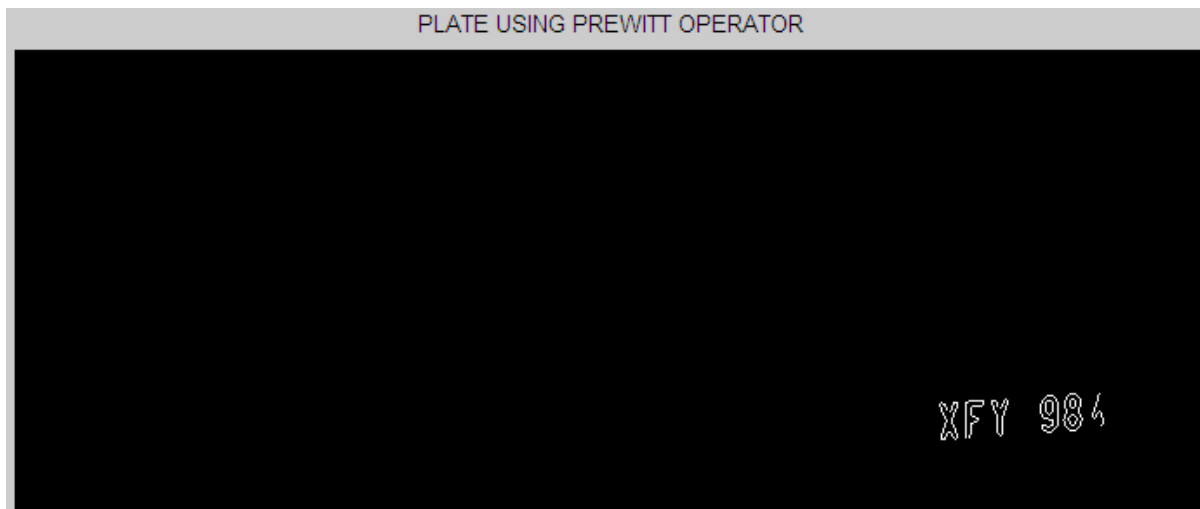


Figure 12: PLATE EXTRACTED USING “PREWITT” OPERATOR

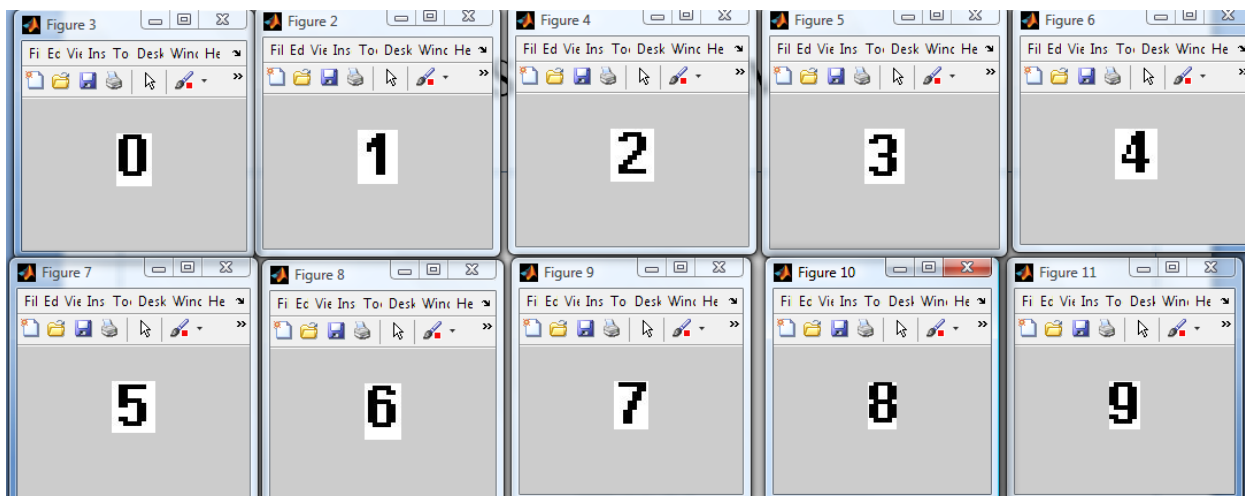


Figure 13: DATASET OF NUMBERS

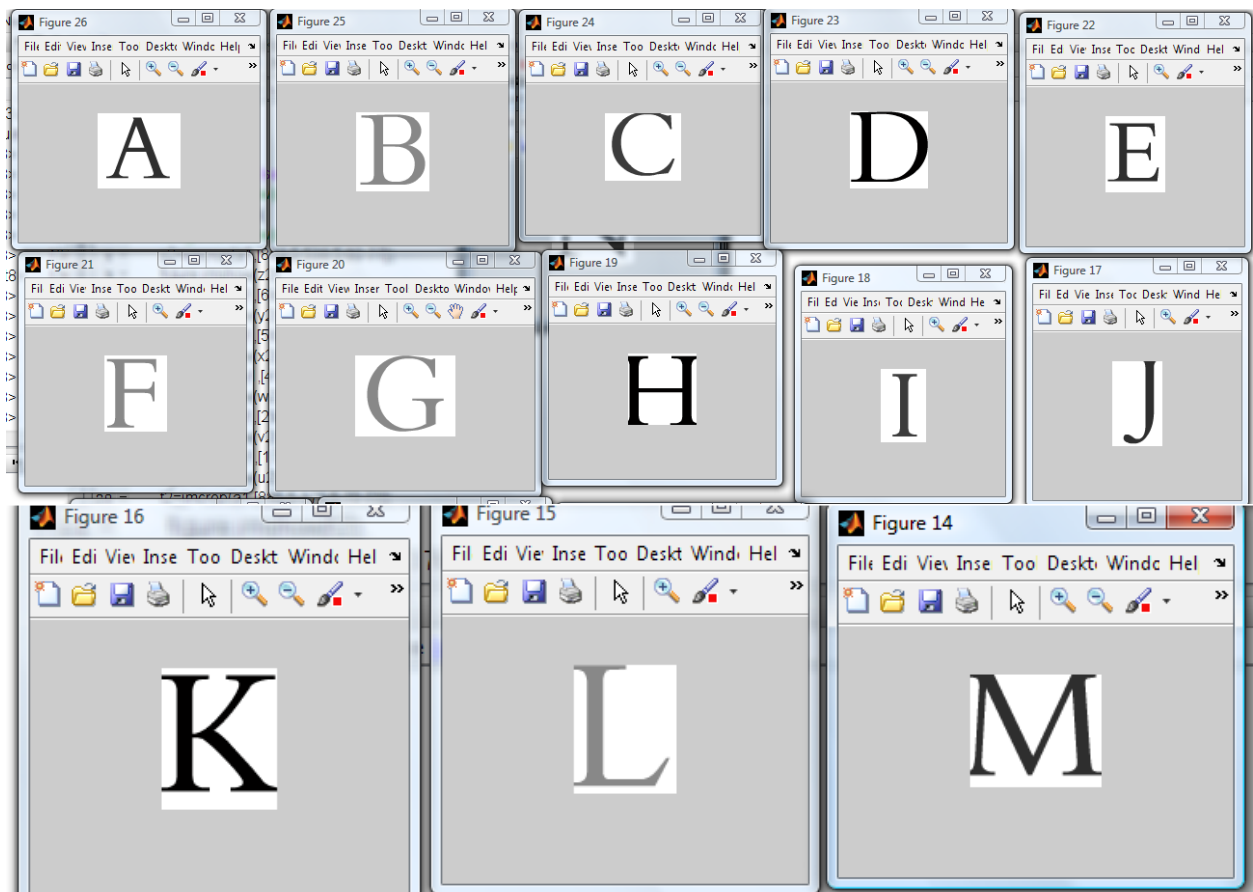


Figure 14: DATASET OF ALPHABETS

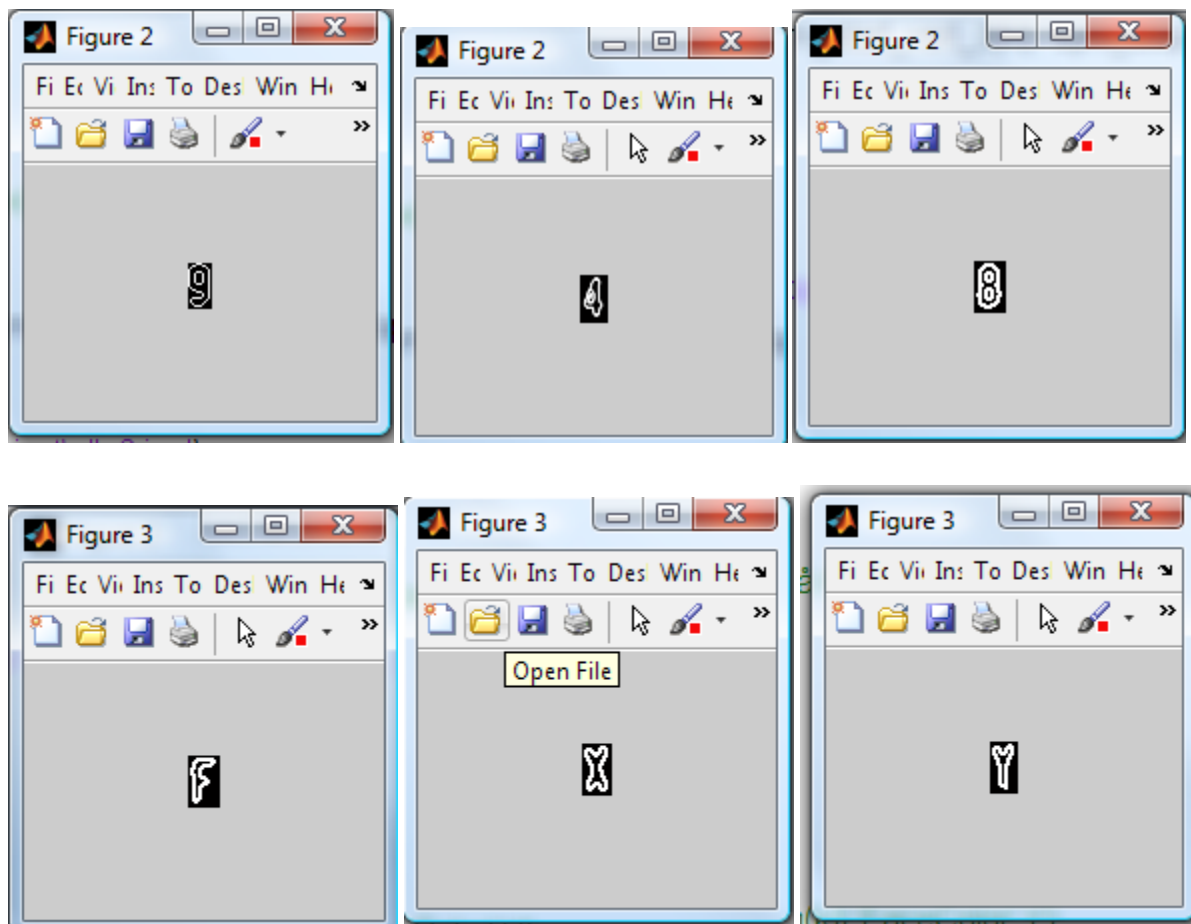
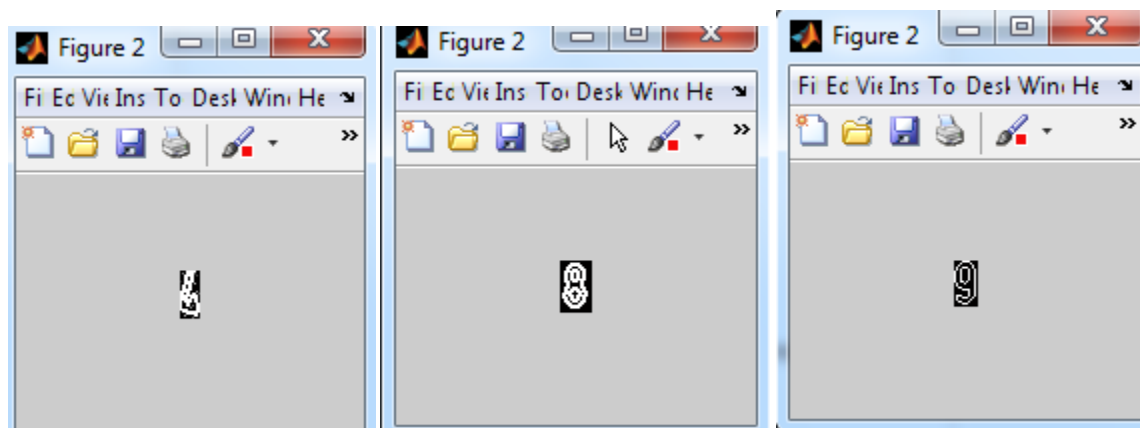


Figure 15: EXTRACETD LETTERS USING “CANNY” OPERATOR



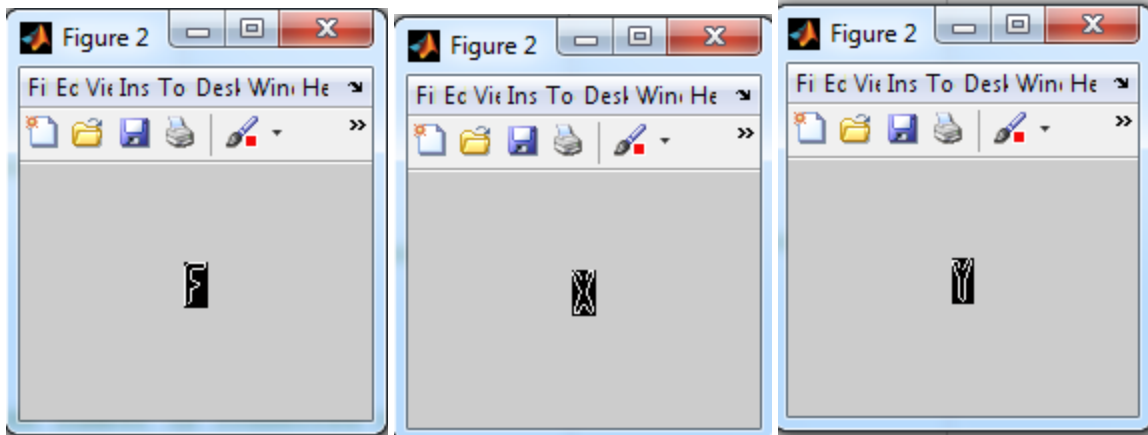


Figure 16: EXTRACETD LETTERS USING “SOBEL” OPERATOR

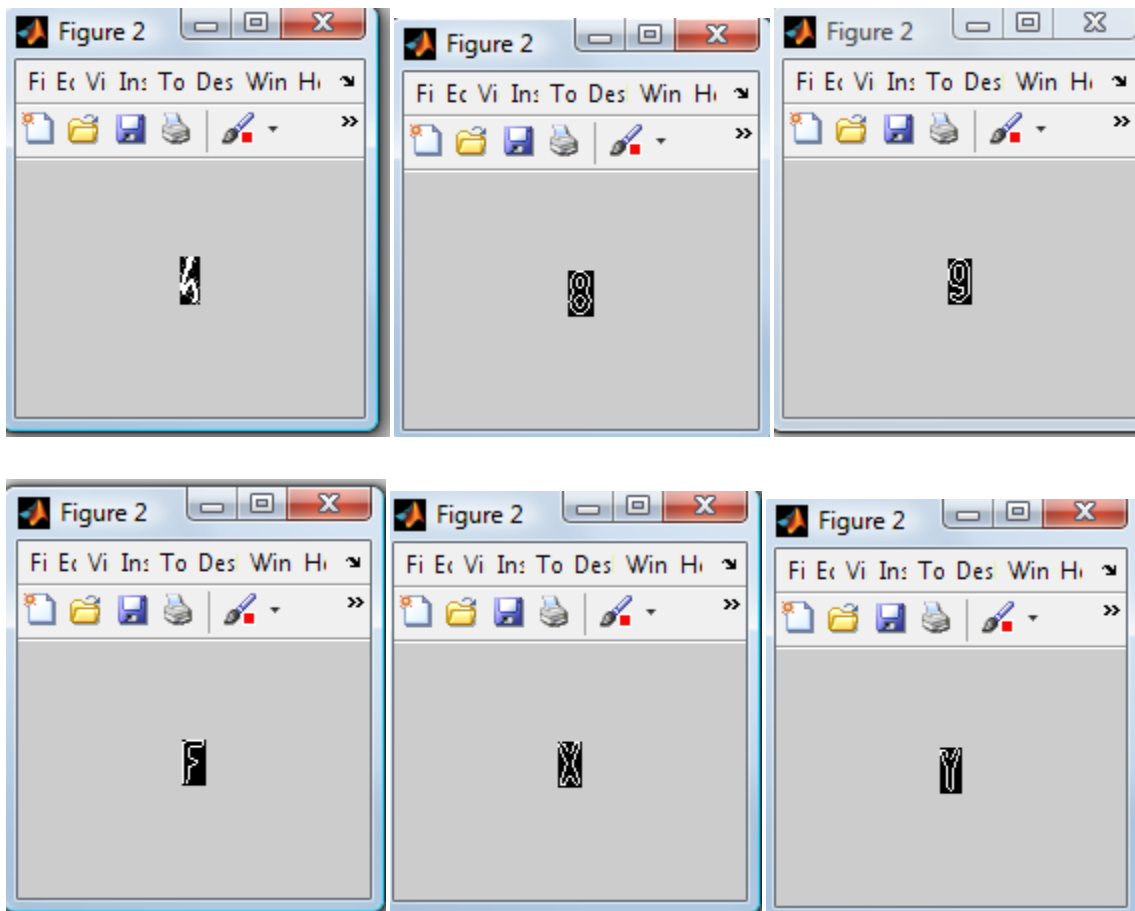


Figure 17: EXTRACETD LETTERS USING “PREWITT” OPERATOR



Figure 18: IMAGE EXTRACTED IN MOTION

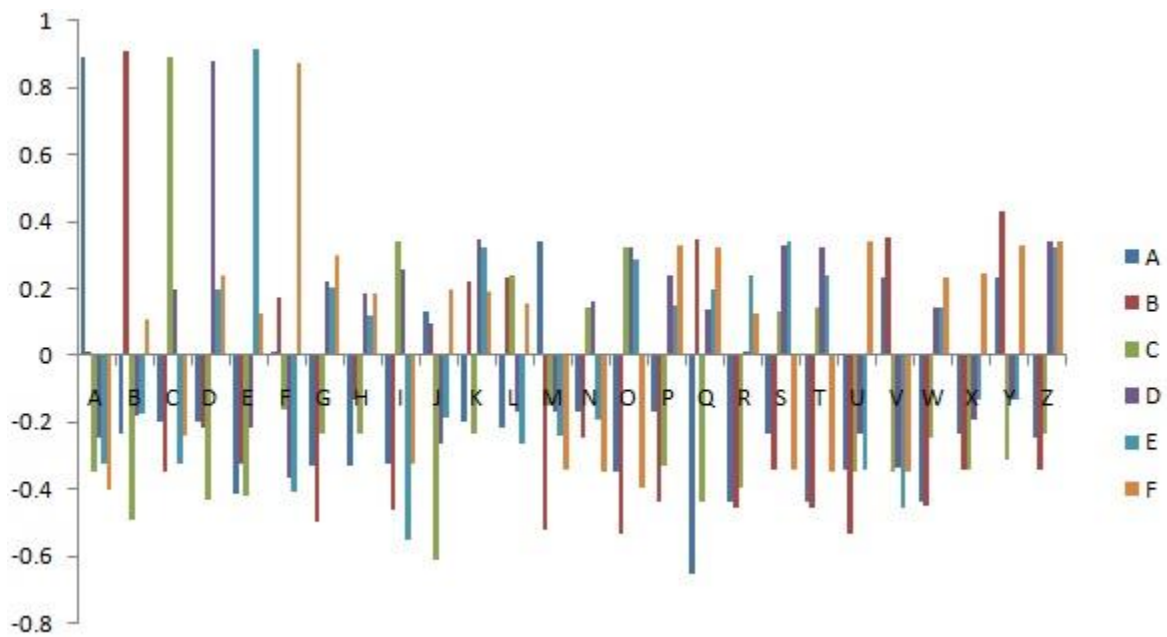


Figure 19 Value of correlation coeff for A,B,C,D,E,F

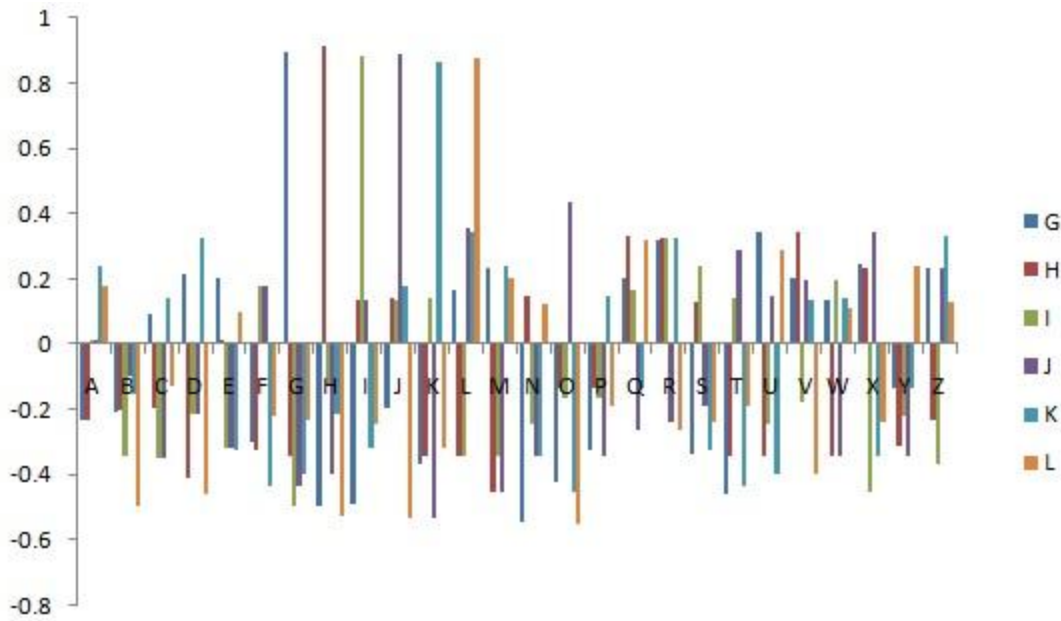


Figure 20 Value of Correlation coeff for G,H,I,J,K,L

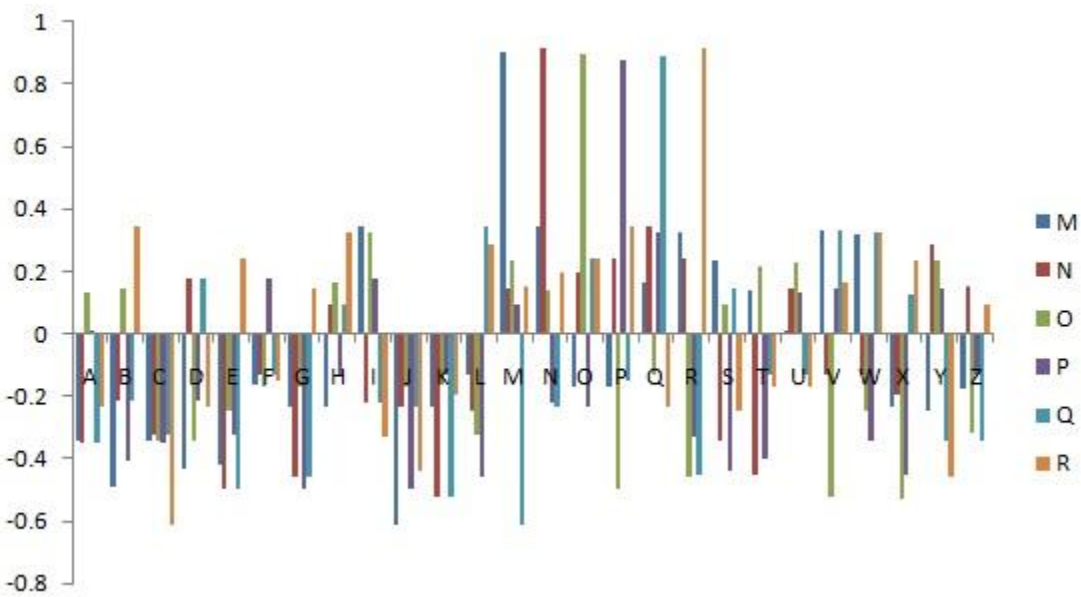


Figure 21 Value of correlation coeff for M,N,O,P,Q,R

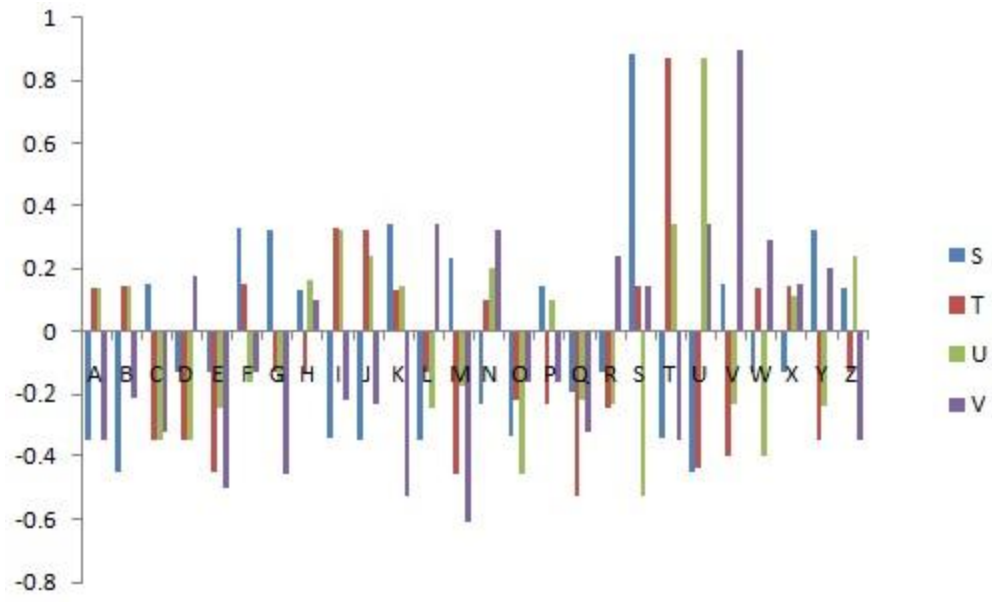


Figure 22 Value of correlation coeff for S,T,U,V

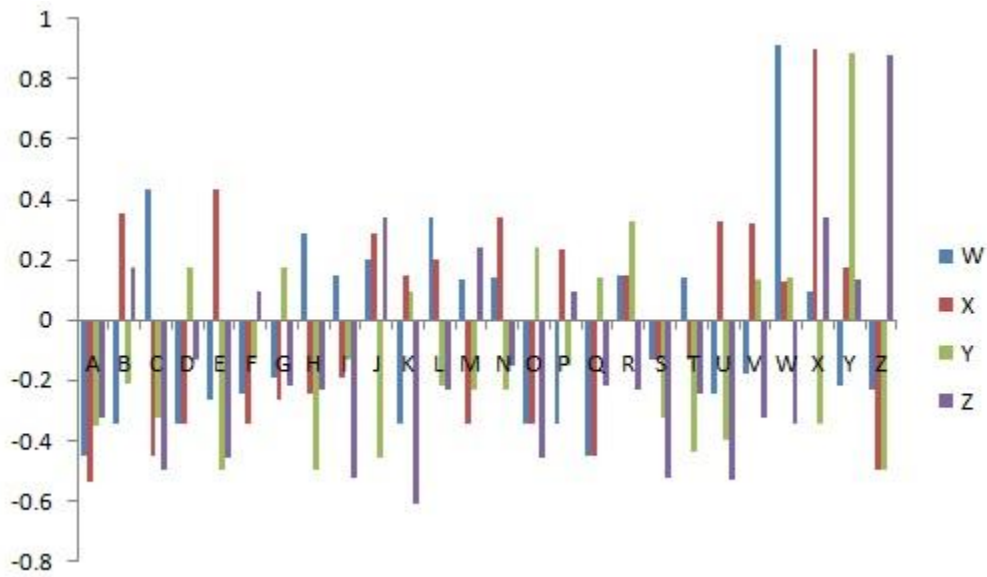


Figure 23 Value of correlation coeff for W,X,Y,Z

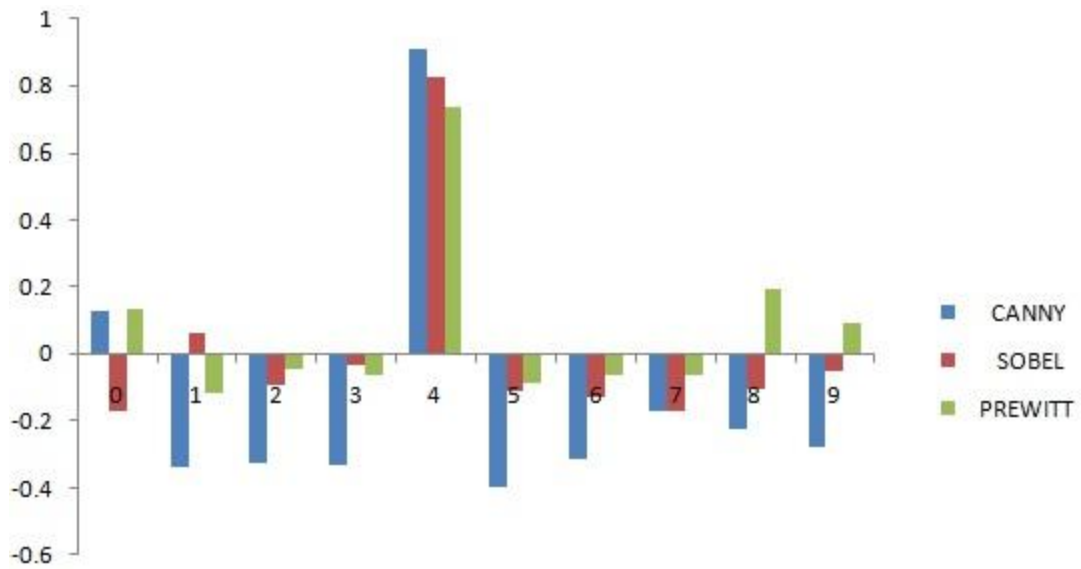


Figure 24 Correlation Coeffs For comparing 9

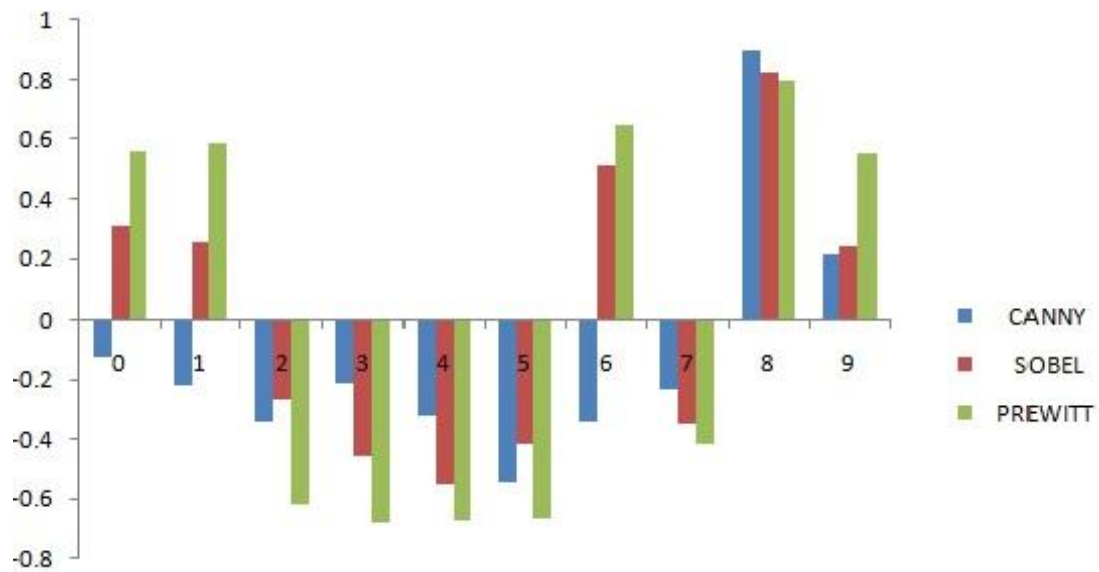


Figure 25 Correlation Coeffs For comparing 8

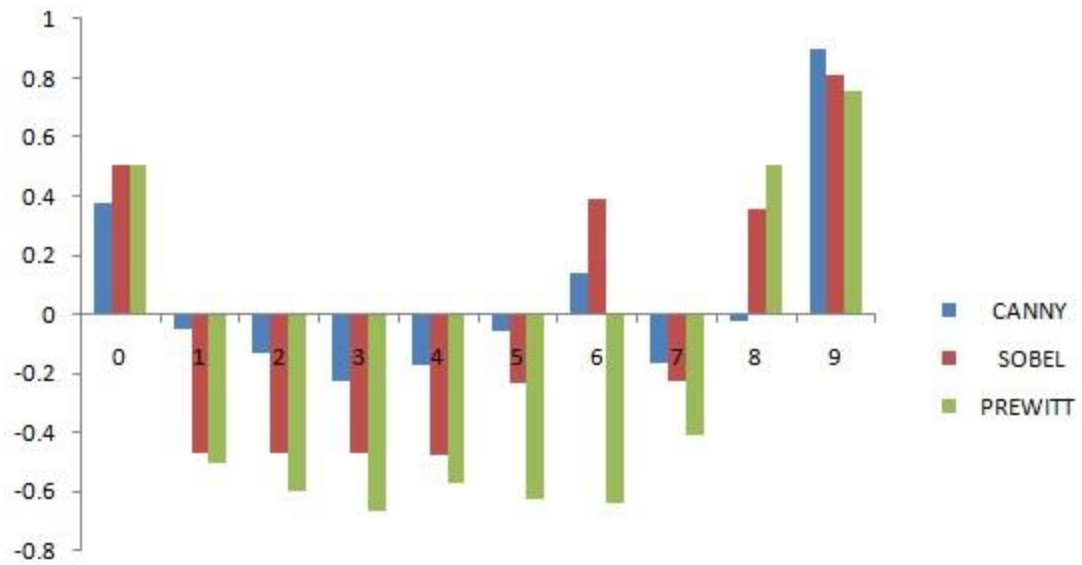


Figure 26 Correlation Coeffs For comparing 9

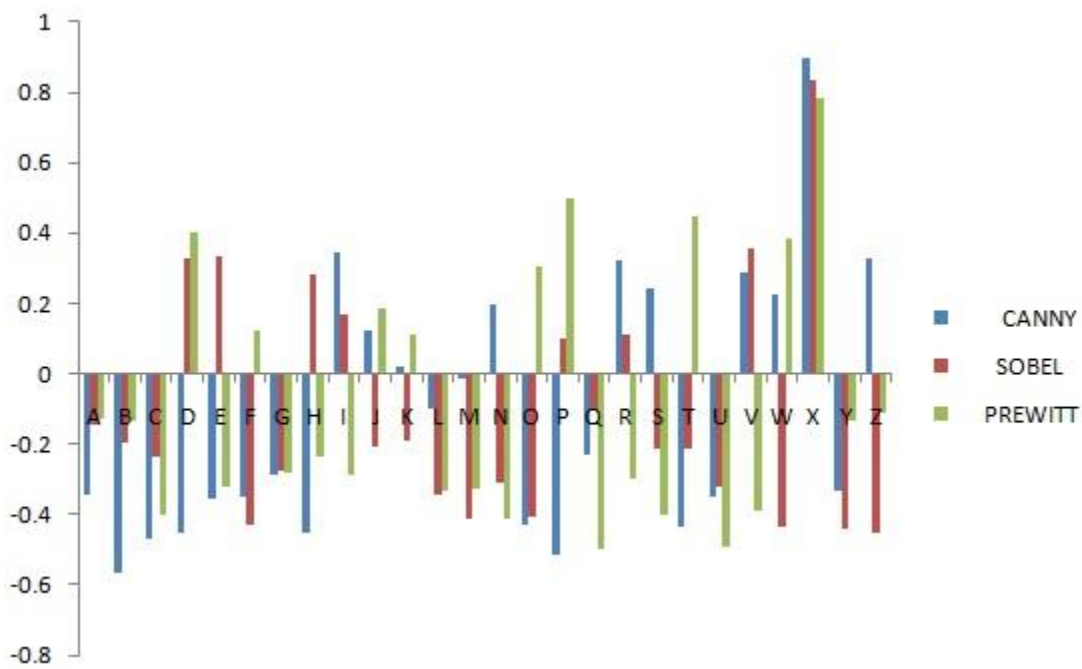


Figure 27 Correlation Coeffs For comparing X

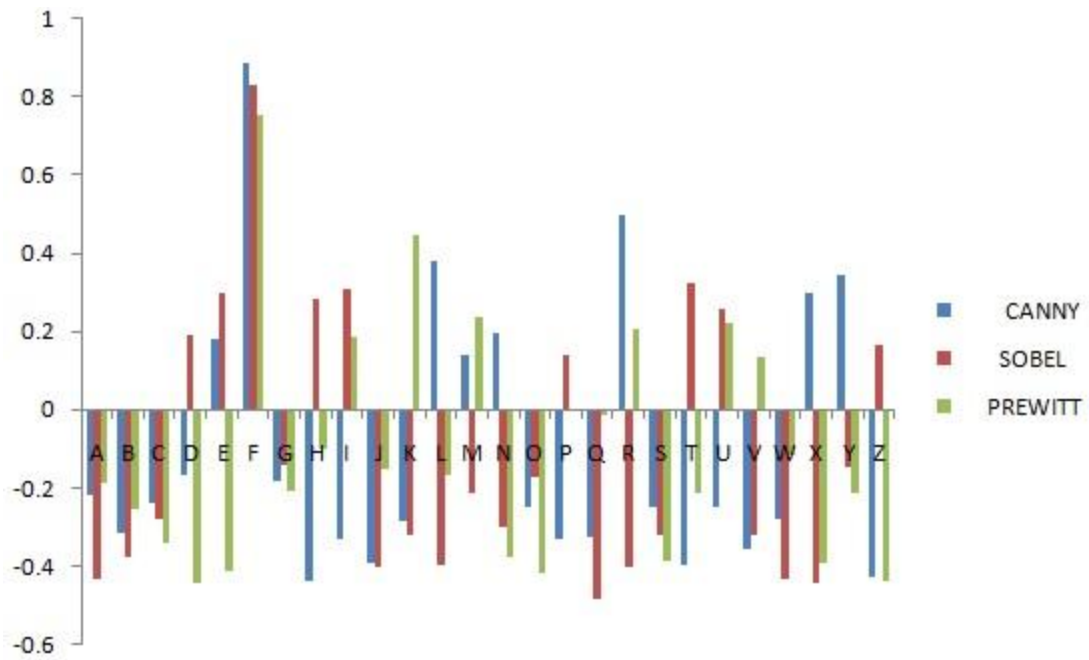


Figure 28 Correlation Coeffs For comparing F

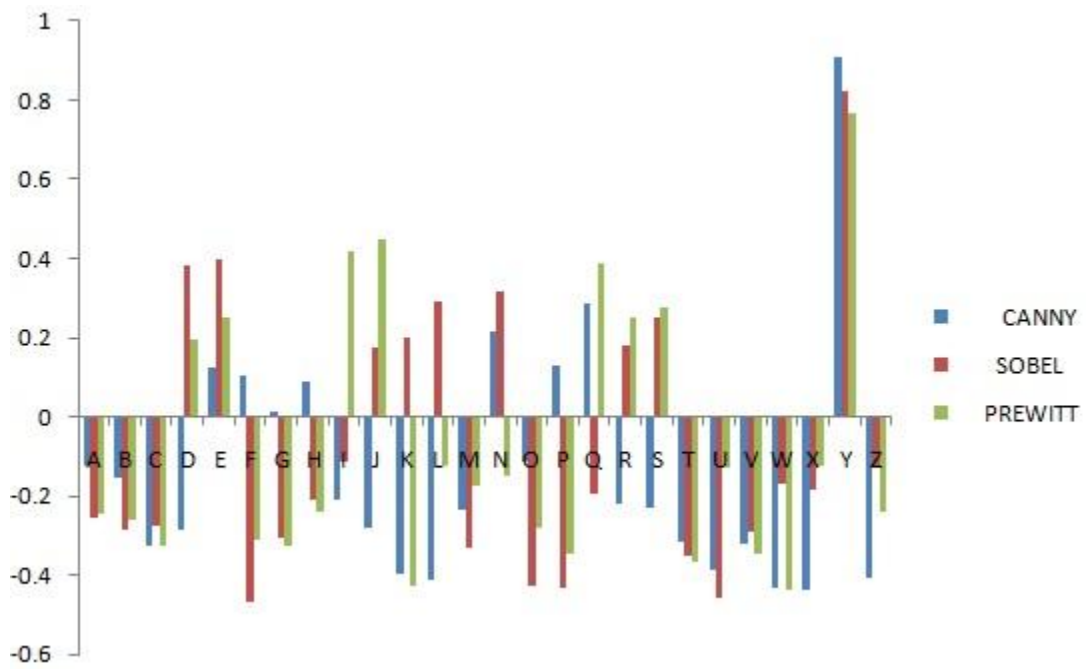


Figure 29Correlation Coeffs For comparing Y

Value of correlation coefficient	CANNY	SOBEL	PREWITT
with '0'	0.3767	0.5048	0.5042
with '1'	-0.048	-0.4661	-0.5042
with '2'	-0.1281	-0.4728	-0.5996
with '3'	-0.2263	-0.4699	-0.6668
with '4'	-0.1741	-0.4793	-0.5705
with '5'	-0.0535	-0.2330	-0.6261
with '6'	0.1413	0.3926	-0.6414
with '7'	-0.1656	-0.2275	-0.4079
with '8'	-0.0205	0.3587	0.5047
with '9'	0.8981	0.8120	0.7571

Table 1: VALUE OF CORRELATION COEFFICINTS WHEN COMPARING "9"

Value of correlation coefficient	CANNY	SOBEL	PREWITT
with '0'	-0.1254	0.3057	0.5578
with '1'	-0.2189	0.2538	0.5873
with '2'	-0.3412	-0.2638	-0.6186
with '3'	-0.2131	-0.4537	-0.6792
with '4'	-0.3211	-0.5505	-0.6752
with '5'	-0.5421	-0.4161	-0.6648
with '6'	-0.3434	0.5096	0.6494
with '7'	-0.2345	-0.3448	-0.4125
with '8'	0.8952	0.8257	0.7985
with '9'	0.2131	0.2429	0.5546

Table 2: VALUE OF CORRELATION COEFFICINTS WHEN COMPARING "8"

Value of correlation coefficient	CANNY	SOBEL	PREWITT
with '0'	0.1248	-0.1750	0.1307
with '1'	-0.3365	0.0594	-0.1173
with '2'	-0.3233	-0.0952	-0.0446
with '3'	-0.3283	-0.0373	-0.0652
with '4'	0.9113	0.8257	0.7368
with '5'	-0.3971	-0.1137	-0.0924
with '6'	-0.3111	-0.1296	-0.0656
with '7'	-0.1715	-0.1754	-0.0644
with '8'	-0.2305	-0.1084	0.1944
with '9'	-0.2775	-0.0549	0.0899

Table 3: VALUE OF CORRELATION COEFFICIENTS WHEN COMPARING "4"

Value of correlation coefficient	CANNY	SOBEL	PREWITT
With 'A'	-0.3452	-0.1463	-0.1275
With 'B'	-0.5643	-0.1933	-0.1347
With 'C'	-0.4673	-0.2351	-0.4027
With 'D'	-0.4536	0.3258	0.4001
With 'E'	-0.3567	0.3322	-0.3207
With 'F'	-0.3498	-0.4321	0.1204
With 'G'	-0.2890	-0.2781	-0.2807
With 'H'	-0.4520	0.2811	-0.2341
With 'I'	0.3456	0.1713	-0.2878
With 'J'	0.1239	-0.2051	0.1873
With 'K'	0.0189	-0.1907	0.1143
With 'L'	-0.0981	-0.3466	-0.3327
With 'M'	-0.0145	-0.4125	-0.3257
With 'N'	0.1987	-0.3092	-0.4099
With 'O'	-0.4321	-0.4087	0.3023
With 'P'	-0.5132	0.1003	0.4985
With 'Q'	-0.2314	-0.1050	-0.4999
With 'R'	0.3214	0.1094	-0.3001
With 'S'	0.2431	-0.2107	-0.4011
With 'T'	-0.4327	-0.2149	0.4498
With 'U'	-0.3485	-0.3227	-0.4898
With 'V'	0.2871	0.3542	-0.3898
With 'W'	0.2253	-0.4377	0.3849
With 'X'	0.8962	0.8345	0.7845
With 'Y'	-0.3334	-0.4411	-0.1311
With 'Z'	0.3257	-0.4532	-0.1086

Table 4 : VALUE OF CORRELATION COEFFICIENTS WHEN COMPARING "X"

Value of correlation coefficient	CANNY	SOBEL	PREWITT
With 'A'	-0.1248	-0.2535	-0.2446
With 'B'	-0.1537	-0.2842	-0.2616
With 'C'	-0.3249	-0.2781	-0.3287
With 'D'	-0.2883	0.3815	0.1940
With 'E'	0.1254	0.3966	0.2490
With 'F'	0.1021	-0.4661	-0.3088
With 'G'	0.0124	-0.3066	-0.3283
With 'H'	0.0878	-0.2106	-0.2413
With 'I'	-0.2098	-0.1132	0.4201
With 'J'	-0.281	0.1752	0.4499
With 'K'	-0.3981	0.1976	-0.4267
With 'L'	-0.4138	0.2916	-0.1256
With 'M'	-0.2377	-0.3300	-0.1729
With 'N'	0.2167	0.3166	-0.1492
With 'O'	-0.1133	-0.4288	-0.2813
With 'P'	0.1284	-0.4316	-0.3486
With 'Q'	0.2867	-0.1944	0.3855
With 'R'	-0.2213	0.1783	0.2490
With 'S'	-0.2314	0.2484	0.2785
With 'T'	-0.3161	-0.3493	-0.3656
With 'U'	-0.3855	-0.4566	-0.1281
With 'V'	-0.3211	-0.2911	-0.3476
With 'W'	-0.4313	-0.1707	-0.4386
With 'X'	-0.4400	-0.1863	-0.1213
With 'Y'	0.9102	0.8213	0.7653
With 'Z'	-0.4091	-0.1248	-0.2425

Table 5 : VALUE OF CORRELATION COEFFICIENTS WHEN COMPARING"Y"

Value of correlation coefficient	CANNY	SOBEL	PREWITT
With 'A'	-0.2167	-0.4313	-0.1858
With 'B'	-0.314	-0.3784	-0.2561
With 'C'	-0.2368	-0.2811	-0.3426
With 'D'	-0.1673	0.1907	-0.4431
With 'E'	0.1781	0.2973	-0.4132
With 'F'	0.8867	0.8301	0.7523
With 'G'	-0.1844	-0.1404	-0.2094
With 'H'	-0.4400	0.2807	-0.1014
With 'I'	-0.3337	0.3087	0.1878
With 'J'	-0.3948	-0.4011	-0.1532
With 'K'	-0.2877	-0.3200	0.4442
With 'L'	0.3813	-0.3990	-0.1694
With 'M'	0.1369	-0.2141	0.2387
With 'N'	0.1967	-0.2989	-0.3774
With 'O'	-0.2487	-0.1713	-0.4157
With 'P'	-0.3324	0.1388	-0.0013
With 'Q'	-0.3249	-0.4831	-0.0124
With 'R'	0.4971	-0.4014	0.2056
With 'S'	-0.2496	-0.3233	-0.3871
With 'T'	-0.3964	0.3248	-0.2133
With 'U'	-0.2488	0.2556	0.2225
With 'V'	-0.3557	-0.3227	0.1343
With 'W'	-0.2779	-0.4314	-0.1184
With 'X'	0.2964	-0.4455	-0.3906
With 'Y'	0.3433	-0.1471	-0.2126
With 'Z'	-0.4279	0.1652	-0.4411

Table 6: VALUE OF CORRELATION COEFFICIENTS WHEN COMPARING "F"

Value of the correlation coeff. With the symbol	A	B	C	D	E	F	G
A	0.8895	0.0123	-0.3456	-0.2456	-0.3214	-0.4001	-0.2341
B	-0.2341	0.9102	-0.4912	-0.1789	-0.1765	0.1092	-0.2098
C	-0.2001	-0.3498	0.8923	0.1982	-0.3267	-0.2376	0.0912
D	-0.1986	-0.2133	-0.4312	0.8798	0.1954	0.2398	0.2156
E	-0.4109	-0.3214	-0.4198	-0.2190	0.9123	0.1256	0.2001
F	0.0098	0.1754	-0.1643	-0.3654	-0.4100	0.8723	-0.2987
G	-0.3278	-0.4981	-0.2367	0.2189	0.1999	0.2999	0.8954
H	-0.3298	-0.1298	-0.2341	0.1871	0.1209	0.1854	-0.4954
I	-0.3267	-0.4598	0.3419	0.2589	-0.5544	-0.3241	-0.4912
J	0.1290	0.0956	-0.6100	-0.2654	-0.1873	0.1982	-0.1947
K	-0.1987	0.2187	-0.2312	0.3456	0.3214	0.1921	-0.3675
L	-0.2187	0.2315	0.2415	-0.1673	-0.2631	0.1543	0.1627
M	0.3410	-0.5241	-0.1526	-0.1678	-0.2416	-0.3415	0.2351
N	-0.1672	-0.2461	0.1425	0.1624	-0.1925	-0.3451	-0.5432
O	-0.3451	-0.5318	0.3241	0.3218	0.2891	-0.3987	-0.4239
P	-0.1678	-0.4398	-0.3276	0.2367	0.1489	0.3298	-0.3254
Q	-0.6532	0.3442	-0.4381	0.1391	0.1982	0.3219	0.2001
R	-0.4376	-0.4562	-0.3985	0.0098	0.2387	0.1276	0.3187
S	-0.2341	-0.3431	0.1328	0.3298	0.3418	-0.3419	-0.3354
T	-0.4356	-0.4581	0.1426	0.3200	0.2387	-0.3459	-0.4598
U	-0.3421	-0.5342	-0.3459	-0.2317	-0.3413	0.3411	0.3451
V	0.2341	0.3541	-0.3451	-0.3343	-0.4532	-0.3451	0.1991
W	-0.4352	-0.4516	-0.2451	0.1425	0.1452	0.2341	0.1342
X	-0.2341	-0.3421	-0.3412	-0.1911	-0.1342	0.2451	0.2431
Y	0.2341	0.4321	-0.3141	-0.1342	-0.1342	0.3314	-0.1342
Z	-0.2451	-0.3431	-0.2341	0.3415	0.3214	0.3412	0.2341

Table 7: Value of correlation coeff. for A, B C, D, E, F, G

Value of the correlation coeff. With the symbol	H	I	J	K	L	M	N
A	-0.2341	0.0123	0.0123	0.2415	0.1754	-0.3456	-0.3498
B	-0.2001	0.9102	0.9102	-0.1526	-0.4981	-0.4912	-0.2133
C	-0.1986	-0.3498	-0.3498	0.1425	-0.1298	0.8923	-0.3214
D	-0.4109	-0.2133	-0.2133	0.3241	-0.4598	-0.4312	0.1754
E	0.0098	-0.3214	-0.3214	-0.3276	0.0956	-0.4198	-0.4981
F	-0.3278	0.1754	0.1754	-0.4381	-0.2187	-0.1643	-0.1298
G	-0.3412	-0.4981	-0.4381	-0.3985	-0.2315	-0.2367	-0.4598
H	0.9113	-0.1298	-0.3985	-0.2133	-0.5241	-0.2341	0.0956
I	0.1328	0.8812	0.1328	-0.3214	-0.2461	0.3419	-0.2187
J	0.1426	0.1328	0.8901	0.1754	-0.5318	-0.6100	-0.2315
K	-0.3459	0.1426	-0.5342	0.8612	-0.3214	-0.2312	-0.5241
L	-0.3451	-0.3459	0.3541	0.3418	0.8745	-0.1298	-0.2461
M	-0.4532	-0.3451	-0.4516	0.2387	0.1999	0.9012	0.1426
N	0.1452	-0.2451	-0.3421	-0.3413	0.1209	0.3456	0.9167
O	-0.1342	-0.1673	0.4321	-0.4532	-0.5544	-0.1673	0.1982
P	-0.1342	-0.1678	-0.3431	0.1452	-0.1873	-0.1678	0.2387
Q	0.3298	0.1624	-0.2631	-0.1342	0.3214	0.1624	0.3418
R	0.3219	0.3218	-0.2416	0.3241	-0.2631	0.3218	0.2387
S	0.1276	0.2367	-0.1925	-0.3276	-0.2416	0.2367	-0.3413
T	-0.3419	0.1391	0.2891	-0.4381	-0.1925	0.1391	-0.4532
U	-0.3459	-0.2456	0.1489	-0.3985	0.2891	0.0098	0.1452
V	0.3411	-0.1789	0.1982	0.1328	-0.4001	0.3298	-0.1342
W	-0.3451	0.1982	-0.3459	0.1426	0.1092	0.3200	-0.1342
X	0.2341	0.8798	0.3411	-0.3459	-0.2376	-0.2317	-0.1925
Y	-0.3141	-0.2190	-0.3451	-0.1342	0.2398	-0.2456	0.2891
Z	-0.2341	-0.3654	0.2341	0.3298	0.1256	-0.1789	0.1489

Table 8: value of correlation coeff. for I, J, K, L, M, N

Value of the correlation coeff. With the symbol	O	P	Q	R	S	T	U
A	0.1328	0.0123	-0.3498	-0.2341	-0.3451	0.1328	0.1328
B	0.1426	0.9102	-0.2133	0.3419	-0.4532	0.1426	0.1426
C	-0.3459	-0.3498	-0.3214	-0.6100	0.1452	-0.3459	-0.3459
D	-0.3451	-0.2133	0.1754	-0.2312	-0.1342	-0.3451	-0.3451
E	-0.2451	-0.3214	-0.4981	0.2415	-0.1342	-0.4532	-0.2451
F	-0.1673	0.1754	-0.1298	-0.1526	0.3298	0.1452	-0.1673
G	-0.1678	-0.4981	-0.4598	0.1425	0.3219	-0.1342	-0.1678
H	0.1624	-0.1298	0.0956	0.3241	0.1276	-0.1342	0.1624
I	0.3218	0.1754	-0.2187	-0.3276	-0.3419	0.3298	0.3218
J	-0.1678	-0.4981	-0.2315	-0.4381	-0.3459	0.3219	0.2367
K	-0.1624	-0.1298	-0.5241	-0.1925	0.3411	0.1276	0.1391
L	-0.3218	-0.4598	0.3419	0.2891	-0.3451	-0.1298	-0.2456
M	0.2367	0.0956	-0.6100	0.1489	0.2341	-0.4598	-0.1789
N	0.1391	-0.2187	-0.2312	0.1982	-0.2317	0.0956	0.1982
O	0.8967	-0.2315	0.2415	0.2387	-0.3343	-0.2187	-0.4598
P	-0.4981	0.8765	-0.1526	0.3418	0.1425	-0.2315	0.0956
Q	-0.1298	0.3241	0.8912	-0.2312	-0.1911	-0.5241	-0.2187
R	-0.4598	-0.3276	-0.4532	0.9134	-0.1342	-0.2461	-0.2315
S	0.0956	-0.4381	0.1452	-0.2451	0.8845	0.1426	-0.5241
T	0.2187	-0.3985	-0.1342	-0.1673	-0.3413	0.8698	0.3419
U	0.2315	0.1328	-0.1342	-0.1678	-0.4532	-0.4381	0.8701
V	-0.5241	0.1426	0.3298	0.1624	0.1452	-0.3985	-0.2312
W	-0.2461	-0.3459	0.3219	0.3218	-0.1342	0.1328	-0.4001
X	-0.5318	-0.4532	0.1276	0.2367	-0.1342	0.1426	0.1092
Y	0.2341	0.1452	-0.3419	-0.4598	0.3214	-0.3459	-0.2376
Z	-0.3141	-0.1342	-0.3459	0.0956	0.1328	-0.1342	0.2398

Table 9: value of correlation coeff for O,P,Q,R,S,T,U

Value of the correlation coeff. With the symbol	V	W	X	Y	Z
A	-0.3498	-0.4516	-0.5342	-0.3498	-0.3214
B	-0.2133	-0.3421	0.3541	-0.2133	0.1754
C	-0.3214	0.4321	-0.4516	-0.3214	-0.4981
D	0.1754	-0.3431	-0.3421	0.1754	-0.1298
E	-0.4981	-0.2631	0.4321	-0.4981	-0.4598
F	-0.1298	-0.2416	-0.3431	-0.1298	0.0956
G	-0.4598	-0.1925	-0.2631	0.1754	-0.2187
H	0.0956	0.2891	-0.2416	-0.4981	-0.2315
I	-0.2187	0.1489	-0.1925	-0.1298	-0.5241
J	-0.2315	0.1982	0.2891	-0.4598	0.3419
K	-0.5241	-0.3459	0.1489	0.0956	-0.6100
L	0.3419	0.3411	0.1982	-0.2187	-0.2312
M	-0.6100	0.1328	-0.3459	-0.2315	0.2415
N	0.3218	0.1426	0.3411	-0.2312	-0.1526
O	-0.1678	-0.3459	-0.3451	0.2415	-0.4598
P	-0.1624	-0.3451	0.2341	-0.1526	0.0956
Q	-0.3218	-0.4532	-0.4532	0.1425	-0.2187
R	0.2367	0.1452	0.1452	0.3241	-0.2315
S	0.1391	-0.1342	-0.1342	-0.3276	-0.5241
T	-0.3459	0.1391	-0.1342	-0.4381	-0.2461
U	0.3411	-0.2456	0.3298	-0.3985	-0.5318
V	0.9001	-0.1789	0.3219	0.1328	-0.3214
W	0.2891	0.9111	0.1276	0.1426	-0.3459
X	0.1489	0.0956	0.8989	-0.3459	0.3411
Y	0.1982	-0.2187	0.1754	0.8877	0.1328
Z	-0.3459	-0.2315	-0.4981	-0.4981	0.8787

Table 10: Value of correlation coeff for V, W, X, Y, Z

CHAPTER 6

CONCLUSION and scope of FUTURE WORK

6.1 Conclusion:

In the above analysis I used three different types of filters to eliminate the noise. They are MEDIAN, AVERAGE and WIENER filters. By seeing the figures 4, 5 and 6 we come to a conclusion that among median, average and wiener filters MEDIAN is the best one.

And I used three different types of operators to extract the number plate characters. They are CANNY, SOBEL AND PREWITT operators. The threshold value used is 0.85. To compare “9” the values of correlation coefficients are 0.8981, 0.8120 and 0.8071 respectively. To compare “8” the values of correlation coefficients are 0.8952, 0.8257 and 0.7985 respectively. To compare “4” the values of correlation coefficients are 0.09113, 0.8256 and 0.7368 respectively.

Similarly the alphabets are also compared. To compare “X” the values of correlation coefficients are 0.8962, 0.8345 and 0.7845 respectively. To compare “F” the values of correlation coefficients are 0.8867, 0.8301 and 0.7523 respectively. To compare “4” the values of correlation coefficients are 0.9102, 0.8213 and 0.7653 respectively.

So for the CANNY operator the value of correlation coefficient is greater than 0.85. So that among the three operators CANNY operator is the best one.

The proposed connected component analysis technique is very easy to implement and we are getting 85% to 90% best results using this technique.

6.2 Limitations:

The above technique is not applicable for figure shown in **fig. 18**. Because that image is extracted when the car is in motion. We cannot find the good connectivity between the edges of that image after the edge detection.

If any other number is present at any part of the image we cannot detect the number plate exactly. This is the main disadvantage of this method.

6.3 Future Work:

In this work I have done the total process in the offline mode. The scope of future work is we can do it by online mode.

If any other number is present at any part of the image we cannot detect the number plate exactly. This is the main disadvantage of this method. This can be eliminated in the future work.

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